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MR. THOMAS C. HOPPER, one of the original founders of the American Meter Company, died at his home, 38 West Walnut lane, Germantown, Philadelphia, Pa., on the morning of the 23d inst. Interment will be made to-morrow.

[OFFICIAL NOTICE.]

March Meeting, Society of Gas Lighting.

OFFICE OF THE SECRETARY, Feb. 25, 1894.

The March meeting of the Society will be held at the works of the Mutual Gas Light Company, New York City, on Thursday, March 8, at 3 o'clock, P.M.

F. S. BENSON, Secretary.

[Special Editorial Correspondence.]

THE '94 MEETING OF THE NEW ENGLAND ASSOCIATION.

YOUNG'S HOTEL, BOSTON, Thursday Morning, Feb. 22, 1894.

Dear JOURNAL: Those who have had any experience with New England winter weather, and it is quite safe to say that almost every gas man in the country has at one time or another in his history found himself in quaint, staid and handsome Boston during the season of cold and snow, need not be told that the back end of February is not the most pleasant in point of atmospheric conditions in the Hub. Still, those who chance it here this week have not very much to complain of in this regard, for while blue skies and bright sunshine were not the visible accompaniment of this year's eve of the anniversary of Washington's natal day, the gray of the day was not of the sort which causes one at this season to occasionally wish with fervor that Boston was somewhat nearer to the Gulf Stream than it actually is. After all, protected by the walls of Young's, what matters it much whether the outer day be dark and dreary. The New England Association, which now celebrates in appropriate fashion its 24th birthday, as usual can rejoice in an excellent attendance, both of members and guests; nor can the delegates be said to be in other than cheerful mood, although the burden of the story of each one is to the effect that business has been undeniably bad. The lucky ones who can report a gain in sendout for the first six weeks of '94 are few indeed; and those who are able to claim a gain for the last six months of '93 are none too many. The consensus of opinion, however, goes to show that the turning point has been reached, and that thrifty New England is almost at the point of again taking on her wonted activity in commercial life. Mill, factory and workshop, scores of which have been in either partial or complete inactivity for months, seem to feel the impulse of renewing life, and the hum and bustle, after so much of lethargy, are pleasing evidences that the profits of the immediate days will speedily wipe out the deficits of the days that brought defeat almost amounting to disaster. As I said, the attendance is excellent, and amongst those from other than the New England States, whose names I now recall, were Messrs. Corbett, Isbell, Seaverns, Page, Shelton, Dickey, Russell, Hayward, Benson, White and Wilkinson. The "Old Guard" of the Association, of course, was fully represented, some of whom could claim that they had "never missed a meeting of the New England." At 10 A. M. Wednesday, President Nettleton called the convention to order, and, working in nice harmony with his fellow-executive, Secretary Prichard, the proceedings were underway in a twinkling, without friction and without noise. The annual reports of the Secretary and Treasurer, which spoke eloquently of the solidity of the Association in matters material, having been disposed of, and the

election for new members having shown the substantial addition of nine names to the rolls, a telegram of congratulation to the Wolverine youngster, then in session at Saginaw, Michigan, was despatched. By this time President Nettleton was ready to deliver the inaugural address, and his presentation of many matters of interest was made with that care and thoroughness which are so characteristic of him. He did not beg the state of trade at all, but reported on it just as he found it from knowledge and information. He finds, just as the figures hitherto given in the JOURNAL indicate, that instead of the usual average gain in send-out of 10 per cent., the figures for the last six months of '93 show a loss of 5 to 10 per cent. all around, which may be taken as proof of a loss of from 15 to 20 per cent. from the normal. He also finds that the panic times have brought more hardship to the suppliers of electric currents than to the suppliers of gas, and completes the reference by admitting that oil as an illuminating agent seems to have gained about all that gas and electricity lost. Some of his deductions in respect of how the the balance is to be restored, as between the three named illuminating agents when the panic times have passed away, are well worth remembering, nor need it be said that they favor gas—and it should be borne in mind that Mr. Nettleton's Company supplies both gas and electricity. The message is a good one, dealing as it does entirely with the practical. Mr. Humphreys' paper was what everyone presumed it would be, a clear, concise, well-studied presentation of the advantages to be derived from the proper working of a combined coal and water gas plant. A good discussion followed, on the termination of which an adjournment was taken. Mr. McKay's paper was a scholarly presentation of how to store and measure enriching oils, and we make no doubt that in its lines are many hints that his brother managers will not be slow to avail themselves of. That he was quite in touch with his subject was shown in the clearness and cleverness with which he responded to the demands upon him during the discussion. Mr. Gifford was responsible for an interesting paper on the subject, "Lime Boxes for Removing CO_2," and although he advanced some things in connection therewith that looked to be well out of the beaten path, it cannot be other than admitted that his paper was entertaining and instructive. The findings of the Committee on the "Effect of Electric Railway Return Currents upon Gas Pipes," I am constrained to say, were disappointing. However, that which was accomplished will be developed later on in the official report; and in any event the Committee was handicapped in many ways. A feature of the meeting was the exhibition of a working sample of the prepayment gas meter. It was exhibited at the instance of the well known Boston meter making house of Tufts, and I think I voice the sentiment respecting the probable success of the prepayment meter in this country by saying that its popularity is not likely to be great. The officers elected for the ensuing year are:

President—Charles H. Nettleton, Birmingham, Conn.
First Vice-President—Charles D. Lamson, Worcester, Mass.
Second Vice-President—Samuel J. Fowler, Springfield, Mass.
Secretary and Treasurer—Chas. F. Prichard, Lynn, Mass.
Directors—C. J. R. Humphreys, Frank S. Richardson, W. R. Addicks, J. A. Coffin, C. D. Sherman.

The banquet at Young's last evening was quite in keeping with the many similar reunions which grace the history of the mother Association. It was largely attended, and not a flaw diminished its sparkle. Being enjoyable it was enjoyed. In fact, everything was as it should have been; for plenty and fraternity ruled the feast. The speech of the evening was made by the Sage of Pawtucket, and it pleased us all to have indubitable proof that his long struggle with illness had not been made in vain. Guests to the number of 90 shared the Association's hospitality.—***

Thursday Evening, Feb. 22.

The weather was delightful all day, and Boston presented a very fine showing, the people generally doing honor to the 162d anniversary of the birth of America's greatest nobleman. The closing proceedings of the convention were marked with the same interest and attention that characterized the opening sessions. The Question Box produced an unusual amount of fruitful matter, and in fact its discussion was one of the features of the meeting. I should have said in my first letter that the Committee on electric currents and effect of same on gas pipes, much to the satisfaction of the Association, was continued, and it is likely an interim report—that is, at some time prior to the '95 convention, will be made.

Mr. Nettleton made an excellent presiding officer, and the entire meeting was brought off in splendid style. From first to last it was thoroughly up to the aims and objects of the New England Association, and was complete in every sense.—***

The Composition of Coal Gas.

[The second of a course of lectures on "The Chemical Technology of Coal Gas," delivered by Professor Vivian B. Lewes, F.I.C., at the Stratford (England) Town Hall.]

The gas which is obtained by the destructive distillation of coal, and which we employ as our chief illuminant, is not a definite compound, but a mechanical mixture of several gases, some of which are reduced to the lowest limit, in order to develop as fully as possible the light-giving properties of the most important constituents of the gas. Analyses of coal gas as supplied at the present time by the great Companies lighting the Metropolis show the composition of the gas to be as follows:

Constituents.	South Metropolitan.	Gas Light and Coke.	Commercial.
Hydrogen	52.22	53.36	52.96
Unsaturated hydrocarbons.	3.47	3.58	3.24
Saturated hydrocarbons...	34.76	32.69	34.20
Carbon monoxide	4.23	7.05	4.75
Carbon dioxide	0 60	0.61	0.75
Nitrogen	4 23	2.50	5.10
Oxygen	0.49	0.21	0.00
	100.00	100.00	100.00

These constituents may be divided into three classes: (*a*) light-yielding hydrocarbons; (*b*) combustible diluents; and (*c*) impurities.

The hydrocarbons, upon which the luminosity of the flame entirely depends, are divided in the analyses into two groups—saturated and unsaturated—according to their behavior with a solution of bromine in potassic bromide, which has the power of absorbing those termed "unsaturated," but not affecting in diffused daylight the gaseous members of the saturated series of hydrocarbons; and they may be separated in the same way by concentrated sulphuric acid, which has the same absorbent effect on the one class, and not on the other.

By the term "hydrocarbons" we mean compounds containing carbon and hydrogen only; and their chief source is the dry distillation of organic bodies, which taking place in Nature, and probably only at a moderate temperature and under pressure, gives the various kinds of petroleum, while when carried out artificially it yields a very large number of gaseous, liquid and solid members of this class of compounds. The hydrocarbons are divided into several series, in each of which the proportion of carbon to hydrogen bears a definite ratio. Taking the letter C as representing 12 parts by weight of carbon, and H as denoting 1 part by weight of hydrogen, the hydrocarbon series present in gas may be represented as follows, *n* standing for the number of times 12 of carbon is found in the body:

(1) The paraffines—$C_n H_{2n+2}$. Methane and ethane, the two simplest members of the group, may be taken as examples. The first of these contains 12 parts by weight of carbon combined with 4 of hydrogen; while ethane contains 24 parts by weight of carbon combined with 6 parts of hydrogen.

(2) The olefines—$C_n H_{2n}$. In this group you always find the carbon and hydrogen combined in the ratio of 12 parts by weight of carbon to 2 of hydrogen.

(3) The acetylenes—$C_n H_{2n-2}$.

(4) The benzines—$C_n H_{2n-6}$.

(5) Naphthaline—$C_n H_{2n-12}$.

The paraffines constitute the saturated hydrocarbons present in the coal gas; and the term "saturated" is applied to them because they contain the maximum amount of hydrogen combined with the carbon.

In coal gas, the simplest member of the paraffine series—methane—is certainly one of the most important constituents; while minute traces of three other members of the series are often present—viz., ethane, propane and butane. Among the unsaturated hydrocarbons present in coal gas, ethylene and benzine vapor play the most important part; while extremely small traces of propylene, butylene, acetylene, crotonylene and naphthaline can be detected by working with very large volumes of gas.

For all practical purposes, we may look upon unenriched coal gas as containing methane, ethylene and benzine vapor as the hydrocarbons which, during combustion, endow coal gas flames with luminosity; and we will now glance at the properties of each separately.

Methane, marsh gas, or light carbureted hydrogen, is formed in Nature by the checked decay of vegetable matter away from direct contact with air, as when vegetation decays under water. For laboratory purposes, the text books direct that it should be made by heating together a mixture of sodic acetate, sodic hydrate and quicklime to a fairly high temperature—an operation which generates a gas containing from 20 to 80

per cent. of hydrogen as well as methane, and probably has given rise to the statement to be found in most works on chemistry that the gas is practically non-luminous. It may be made pure in small quantities by acting on methyl iodide and methylic alcohol with zinc on which copper has been deposited. But the action is very slow if carried on at low temperatures; and the gas is impure if the reagents are warmed to 30° to 40° C. The gas can also be prepared by acting on zinc methyl with water. The operation, however, is not devoid of danger; and the zinc methyl is extremely troublesome to make and costly to buy, consequently the manufacture of pure methane in any quantity presents considerable difficulties.

The illuminating power of the gas, when burnt in the standard argand burner, is given by Mr. Lewis T. Wright at 5.2 candles per 5 cubic feet; but a far higher illuminating value can be obtained from it at a higher temperature—*i. e.*, when consumed in a regenerative burner, where it becomes nearly as luminous as 16-candle coal gas. A cubic foot of methane requires 2 cubic feet of oxygen or 10 cubic feet of air for its complete combustion; and in burning it forms 1 cubic foot of carbon dioxide and 2 cubic feet of water vapor.

Methane is only slightly soluble in water, 100 volumes of which take up 5.4 volumes of the gas at 0° C. It is a tasteless, colorless and nonodorous gas, with no distinctive poisonous action, and can be liquefied by the combination of great cold and pressure. It has a very high point of ignition; hence the flame is easily extinguished by cooling, as seen in the action of the Davy safety lamp. The specific gravity of methane is .553, and it is present in coal gas to the extent of from 30 to 40 per cent.

Ethylene, olefiant gas, or heavy carbureted hydrogen, is one of the chief gaseous products of the destructive distillation of organic substances; and in it 24 parts by weight of carbon are combined with 4 parts of hydrogen to yield 28 parts of the gas. In preparing it for experimental work, 25 parts by weight rectified methylated spirit are heated in a flask with 150 parts of strong sulphuric acid—the bottom of the flask being covered with sand to prevent frothing, and the gas evolved is then passed through wash bottles containing sulphuric acid and caustic soda respectively, to wash it from alcohol vapor and sulphur dioxide. It is a colorless gas with a sweetish taste, is not poisonous, and is only soluble to the extent of 8 volumes in 100 volumes of water. When mixed with its own volume of chlorine, and allowed to stand, it forms an oily liquid, from which it derives its name of "olefiant gas;" but if mixed with double its volume of chlorine and a light applied, the chlorine unites with the hydrogen of the gas, and the carbon is set free as a cloud of soot. When subjected to the action of heat, ethylene is converted into a mixture of methane and acetylene; while at a sufficiently high temperature, these are again decomposed into carbon and hydrogen.

Ethylene requires for its combustion a larger proportion of oxygen than is the case with methane—1 cubic foot of ethylene combining with 3 cubic feet of oxygen to form 2 cubic feet of carbon dioxide and 2 cubic feet of water vapor; and in order to obtain the quantity of oxygen, the combustion of a cubic foot of the gas will require 15 cubic feet of air. The illuminating value of pure ethylene may be taken as being 70 candles per 5 cubic feet, as Dr. Percy Frankland found that a sample of the gas containing 97.5 per cent. of ethylene gave, as a mean of four experiments, an illuminating value of 68.5 candles. The gas differs from methane by the ease with which it is acted upon by chlorine, bromine and sulphur trioxide.

Benzine (C_6H_6) is a liquid which can be obtained from some samples of petroleum, but more abundantly from the light oil distilled from coal tar. It is obtained from the light oil by fractional distillation; the portion which comes over between 79° and 82° C., consisting to a considerable extent of benzine, which is purified by cooling it with a freezing mixture of ice and salt, when benzine crystallizes, and can be separated from the other hydrocarbons present, which remain liquid, by draining and pressing. The liquid benzine is volatile, and its vapor burns with a heavy red smoky flame. It is not possible to burn the pure liquid hydrocarbon for the development of light, even in specially constructed lamps, on account of the difficulty of obtaining a smokeless flame, and therefore we are obliged to rely upon data obtained by taking the effect of known quantities of benzine vapor diffused in combustible gases, such as hydrogen. Determined in this way, the illuminating value of benzine per 5 cubic feet of its vapor is 420 candles, as determined by Drs. Frankland and Thorne, and 820 as determined by Knublauch. A cubic foot of benzine vapor would require for its complete combustion 7½ cubic feet of oxygen, or 37½ cubic feet of air; and it would yield, as products of combustion, 6 cubic feet of carbon dioxide and 3 cubic feet of water vapor. It is the enormous quantity of air required for its combustion that renders it almost impossible to consume it in such a way as to bring out its illuminating value. Benzine vapor is slightly soluble in water, and very soluble in alcohol and ether, and is itself an excellent solvent for fats and caoutchouc, its presence giving solvent naphtha its most valuable properties.

Another hydrocarbon which is present in only minute quantities in the coal gas itself, but is developed in the changes taking place in the flame, and plays a very important part in causing luminosity, is acetylene (C_2H_2), which is the only hydrocarbon that has been formed by the direct union of its constituents; the gas being produced when the electric arc is formed between carbon terminals in an atmosphere of hydrogen. It is a gas with a peculiar and penetrating odor, which may be noticed when an atmospheric burner catches light at the bottom of the tube, or indeed during any process of checked combustion. Water at ordinary temperatures dissolves its own volume of the gas; and this is why it is present in such small quantities in coal gas, as scrubbing and storage practically remove it. One cubic foot of the gas requires 2½ cubic feet of oxygen, or 12.5 cubic feet of air, for its complete combustion, and it yields 2 cubic feet of carbon dioxide and 1 cubic foot of water vapor as the products. It burns with a rich smoky flame, but its illuminating value has not yet been determined, owing to the difficulty in storing any quantity—the gas being soluble in any liquid which could be used on a large scale. When ordinary chemical combination takes place, heat is evolved, and before the compounds formed can be again broken up, the same amount of heat has to be absorbed by the body as was given out during its formation. Such compounds are called "exothermic," and the greater the amount of heat given out during their formation, the more stable are they. In the formation of acetylene and some other compounds, heat is absorbed instead of being given out; and such bodies are called "endothermic," and evolve heat on decomposition, which renders them easy to break up, while the heat given out carries on the action with great rapidity when once started. Acetylene can be decomposed by the detonation in it of mercuric fulminate, yielding hydrogen and a cloud of carbon.

The light-giving power of coal gas is undoubtedly entirely due to the hydrocarbons, and the idea held up to 16 years ago was that the illuminating value depended upon the amount of ethylene present. This, however, is manifestly incorrect, as, if it were true, 4 per cent. of ethylene mixed with 96 per cent. of a combustible diluent such as hydrogen should give a 16 to 17-candle gas, whereas a mixture of 10 per cent. of ethylene and 90 per cent. of hydrogen is devoid of luminosity. In 1876 Berthelot came to the conclusion that the illuminating value of the Paris coal gas was almost entirely due to benzine vapor. But here again another mistaken idea arose, owing to a faulty method of estmating the benzine; and my own opinion is that methane is certainly one of the most important of the hydrocarbons present, when the gas is burnt in such a way as to evolve from it its proper illuminating power, while the benzine vapor, small as the quantity is, comes next in importance, and ethylene last. It is the combined action of the hydrocarbons which gives the effect; not any one of them acting alone.

We must now turn to the properties of the combustible diluents, which give volume to the gas, as we shall realize later that they also have an effect, although a negative one, upon the light emitted by the flame. The most important of these is the hydrogen, which constitutes about half the volume of ordinary coal gas.

Hydrogen is rarely found free in Nature, although in combination it forms one-ninth by weight of water, and also occurs in ammonia, sulphureted hydrogen, and in all vegetable and animal tissues. It was known to the ancients under the name of "inflammable air;" but it was not until 1766 that its properties were investigated by Cavendish. The most convenient method of preparing hydrogen is by acting on dilute sulphuric acid with metallic zinc. For this purpose granulated zinc is placed in a bottle fitted with a cork, through which pass a thistle funnel and an exit tube. Enough water is added to cover the zinc; then sulphuric acid is added, a few drops at a time, by means of the thistle funnel. An immediate evolution of the gas takes place, and it is conducted by the leading tube below the surface of the water in a pneumatic trough, where it can be collected in cylinders by the displacement of water. The first portions of gas which escape must not be taken, being an explosive mixture of hydrogen and the oxygen of the air which originally filled the generating bottle. The reaction which takes place during the formation of the hydrogen may be represented by the following equation:

Zinc.		Sulphuric Acid.		Zinc Sulphate.		Hydrogen.
Zn	+	H_2SO_4	=	$ZnSO_4$	+	H_2

In its physical properties, hydrogen is most unmistakably nonmetallic; but in all its chemical relations with other elements it behaves so like a metal that, in considering the reactions in which it takes part,

we look upon it as one. In the preparation of hydrogen from zinc and hydric sulphate, we have the hydrogen atoms turned out of their combination with the sulphur and oxygen by the chemically stronger metal zinc. In the same way we can replace the hydrogen in water by certain other metals, which, combining with the oxygen, set free the gaseous hydrogen. If we pass steam—the vapor of water—over iron raised to a dull red heat, the iron combines with the oxygen, forming an oxide of iron, while the hydrogen escapes free. The interchange of metals we may represent by the following equation:

Water Vapor.		Iron.		Black Magnetic Oxide of Iron.		Hydrogen.
$4(H_2O)$	+	$3Fe$	=	Fe_3O_4	+	$4H_2$

This method of obtaining hydrogen is perhaps the cheapest and best when large quantities of the gas are required.

Some metals, like iron, have the property of decomposing water at a red heat; others, like sodium and potassium, break it up at ordinary temperatures, while gold and silver are unable to decompose it at all. If sodium is placed in contact with water, a violent action takes place, and one-half of the hydrogen of the water is liberated, the sodium combining with the remainder of the hydrogen and oxygen to form sodic hydrate.

Sodium.		Water.		Sodic Hydrate.		Hydrogen.
Na_2	+	$2(H_2O)$	=	$2(NaHo)$	+	H_2

The same chemical reaction takes place when potassium is thrown on water; but in this case the heat generated by the combination of the metal with the oxygen and part of the hydrogen is so great that the escaping gas is set on fire.

Potassium.		Water.		Potassic Hydrate.		Hydrogen.
K_2	+	$2(H_2O)$	=	$2(KHO)$	+	H_2

In these two cases only half the hydrogen contained in the water is liberated; but if the sodic hydrate or potassic hydrate be again acted upon with excess of sodium or potassium, the remaining atom of sodium is turned out:

Sodic Hydrate.		Sodium.		Sodic Oxide.		Hydrogen.
$2(NaHO)$	+	Na_2	=	$2(Na_2O)$	+	H_2

By whichever method prepared, hydrogen when pure is a colorless gas, without taste or odor. It has no poisonous action on life, and may be breathed for a few moments; but it will destroy life when inhaled for any length of time, by excluding from the lungs the oxygen of the air required for respiration. Hydrogen has no action on test-papers or lime water; it does not support combustion, but itself burns, in contact with oxygen, with a non-luminous, but intensely hot flame—water being the only product of its combustion. In burning, it produces a greater heat than the same weight of any other known substance—1 lb. of hydrogen on combining with 8 lbs. of oxygen giving out sufficient heat to raise 34,462 lbs. of water through one degree Centigrade.

All gases, with the exception of hydrogen, have been condensed to a liquid by cold and pressure, or the two combined; but hydrogen, even when subjected to a pressure of 110 atmospheres, and at the same time cooled to a temperature of—213.8°C., shows no sign of liquefaction. It is the lightest body known—being 14.47 times lighter than air; and hence it is taken as the standard with which the weight of all other gases is compared. The ratio by weight which a gas bears to an equal volume of hydrogen is called its density. Hence, when we say that the density of oxygen is 16, we mean that any volume of oxygen will weigh 16 times as much as the same volume of hydrogen measured under similar conditions of temperature and pressure. A cubic foot of hydrogen when burnt combines with half a cubic foot of oxygen to form a cubic foot of aqueous vapor.

The second of the combustible diluents—carbon monoxide—exists in coal gas in proportions which vary from 3 to 8 per cent. It is a colorless, tasteless gas, highly poisonous, and very little soluble in water. It does not support combustion, but burns with a pale blue flame—taking up another atom of oxygen, and becoming carbon dioxide. It may be prepared by acting upon oxalic acid with sulphuric acid; oxalic acid consisting of hydrogen, carbon, and oxygen in the proportions necessary to form water, carbon monoxide, and carbon dioxide. When this is heated with sulphuric acid, the elements of water are taken up by the sulphur, and carbon monoxide and dioxide are set free. These mixed gases are now led through sodic hydrate, which absorbs the carbon dioxide, forming sodic carbonate and water, and the monoxide passes on free. The action may be represented as follows:

Oxalic Acid.		Sulphuric Acid.		Dilute Sulphuric Acid.		Carbon Monoxide.		Carbon Dioxide.
$H_2C_2O_4$	+	H_2SO_4	=	$H_2SO_4H_2O$	+	CO	+	CO_2

Carbon Monoxide.		Carbon Dioxide.		Sodic Hydrate.		Sodic Carbonate.		Water.		Carbon Monoxide.
CO	+	CO_2	+	$2(Na_2HO)$	=	Na_2CO_3	+	H_2O	+	CO

When carbon dioxide is passed over red-hot charcoal, the dioxide gives up one-half its oxygen to the carbon, and forms twice its own volume of carbon monoxide:

Carbon Dioxide. 2 Vols.		Carbon.		Carbon Monoxide. 4 Vols.
CO_2	+	C	=	$2(CO)$

The blue flame of carbon monoxide may often be seen on the top of a clear coke fire; and its formation may be explained in the following way: At the bottom of the fire, the fuel is in contact with excess of air drawn through it by the updraught of the chimney; and here the fuel burns to water and carbon dioxide. Carbon dioxide passing up through the red-hot coke becomes reduced to carbon monoxide; and this in turn coming in contact with more air at the top of the fire, burns with its characteristic pale blue flame, again forming carbon dioxide, which, with the water vapor and nitrogen of the air passes up the chimney.

Carbon monoxide has a powerful reducing action, and under the influence of heat, will take oxygen from several of the metallic oxides; forming carbon dioxide, and leaving the metal free—an action which is utilized in metallurgical processes. The gas has such powerful poisonous properties, that 1 per cent. of it in air renders the air perfectly unfit to breathe; and many fatal accidents have arisen from its being formed during checked combustion, as when metallic surfaces cooled on one side by water are exposed to a gas flame, as is found in some forms of water-heaters, as well as by the imperfect combustion taking place in kilns, in slow-combustion stoves, and in charcoal pans. It may be distinguished from carbon dioxide by burning with a blue flame, and not affecting lime water until combustion has converted it into carbon dioxide.

Inasmuch as both of these diluents burn, and, volume for volume, emit nearly the same amount of heat, it would at first sight seem natural to suppose that they would act to about the same degree upon the illuminating value of the hydrocarbons present. This, however, is not the case.

The action of the diluents in coal gas upon its light-giving property has been determined by taking ethylene, with an illuminating power of 68.5 candles, as a representative of the hydrocarbons, and diluting with the various constituents of coal gas. By this process the following results were obtained by Dr. Percy Frankland:

Combustible Constituents.

Diluent,	Percentage of Ethylene.	Percentage of Diluent.	Candle Power per 5 Cu. Ft. per Hour
Hydrogen	77.55	22.45	54.58
	68.39	31.61	49.37
	53.58	46.42	39.21
	35.47	64.53	30.85
	26.08	73.92	22.84
	13.37	86.63	6.73
	10.00	90.00	0.00
Carbon monoxide	81.65	18.35	55.27
	67.75	32.25	47.73
	46.30	53.70	33.09
	37.94	62.06	26.52
	28.73	71.27	13.26
	23.89	76.11	6.56
	20.00	80.00	0.00
Methane	85.67	14.33	57.91
	69.09	30.91	47.88
	57.74	42.26	40.42
	35.90	64.10	33.17
	13.00	87.00	19.35
	6.87	92.13	17.59

These results show that, with the combustible constituents, hydrogen reduces the illuminating power least with large quantities of hydrocarbons, but that methane is preferable when in excess, as with low percentages of the illuminant, especially when burnt at a high temperature, methane itself becomes an illuminating agent. This is due to the fact that, although when marsh gas or methane burns at ordinary temperatures it is non-luminous, at a high temperature some of it is broken up into acetylene, which gives it luminosity.

Carbon monoxide is the most injurious of the combustible diluents, 80 per cent. mixed with ethylene rendering it non-luminous—a result which would require 90 per cent. of hydrogen. It has been pointed out, however, that the general illuminating effect of a flame is not due to any one hydrocarbon, but to the joint action of several; and I have made experiments to see how far these results held good when oil gas, consisting of rich mixtures of saturated and unsaturated hydrocarbons, was diluted with poor coal gas, hydrogen, and carbon monoxide respectively.

In the following experiments, I first tried the effect of enrichment by known percentages of oil gas upon the original coal gas, and then upon

the combustible diluents separately. The oil gas for this purpose was made by decomposing Russian distillate oil at 1,600° F. in a Paterson oil gas plant; collecting the gas into a 400 cubic foot holder, and running the right proportions into experimental holders, into which the diluting gas was afterward passed, and the mixture allowed to stand all night, to insure thorough mixing. In testing the various mixtures the gas was burnt at the burner which suited it best, and the rate of flow was regulated to give the most perfect obtainable flame, and the consumption of gas calculated to 5 cubic feet per hour. The whole of each mixture was burnt, and tests were made every half hour, so as to insure detection of imperfect mixing—the mean of the tests being taken as representing the illuminating value of the gas. All tests were carried out on an Evans-Sugg photometer, with the usual precautions and corrections.

Taking first the coal gas, and enriching it with oil gas, the following results were obtained:

Illuminating value of the original coal gas..... 13.43 candles.
Illuminating value of the oil gas..... 48.90 candles.

Percentage of Coal Gas.	Percentage of Oil Gas.	Illuminating Value of the Mixture. Found.	Calculated.
95	5	16.2	15.20
90	10	17.5	16.97
75	25	23.2	22.29
50	50	32.3	31.16
25	75	44.5	40.02

The coal gas used was rendered poor in illuminating value by standing for some time, and the results clearly show that a considerably higher result is obtained than would be expected from calculation.

Having determined the result of diluting the rich oil gas with coal gas, the next step was to find out how the chief diluents acted towards the enricher. Hydrogen, being the most abundant constituent of the coal gas, was tested first; the same methods of testing being observed as in the case of the coal gas. The hydrogen used contained 99.6 per cent. of the gas; and, as before, the oil gas was first put into the test holders and the hydrogen then added—the same precautions being taken to insure mixing as before.

Set I.

Illuminating value of the original oil gas..... 49.6 candles.

Percentage of Hydrogen.	Percentage of Oil Gas.	Illuminating Value of the Mixture. Found.	Calculated.
33.3	66.6	34.2	33.0
50.0	50.0	25.5	24 8
66.6	33.3	18.2	16.5

Set II.

Illuminating value of the original oil gas..... 42.8 candles.

Percentage of Hydrogen.	Percentage of Oil Gas.	Illuminating Value of the Mixture. Found.	Calculated.
25.0	75.0	32.8	32.1
50.0	50.0	23.9	21.4
60.0	40.0	21.0	17.1
66.6	33.3	12.4	14.2
71.4	28.5	9.0	12.2

These experiments show that with hydrogen gas the illuminating value of the mixture is higher than one would expect from calculations for candle powers higher than 18; but that, when diluted below that value, the excessive dilution causes a loss of lighting power, and so necessitates a larger addition of the enriching gas than that calculated.

The next combustible diluent experimented with was carbon monoxide, which has an interest for us as being not only the cheapest combustible gas, but also the most poisonous, the numerous accidents which have arisen from the use of water gas being due to its presence.

Illuminating value of the original oil gas... 54.7 candles.

Percentage of Carbon Monoxide.	Percentage of Oil Gas.	Illuminating Value of the Mixture. Found.	Calculated.
90	10	unreadable	5.4
75	25	8.94	13.6
50	50	21.50	27.3
25	75	38.40	41.0

These experiments show that, even when only a small percentage of carbon monoxide is used, it has a tendency to reduce the illuminating value of the mixture; while in order to make a 17 or 18-candle power gas with carbon monoxide as the basis, a large excess of hydrocarbon gas would have to be used.

Having seen that admixture with hydrogen gives higher results than would be expected, while carbon monoxide seriously detracts from the illuminating value of gas, it might be expected that with water gas—a mixture of the two, theoretically in nearly equal proportions—the one would neutralize the other, and that the results obtained would be nearly proportional to the amount of oil gas used. Experiment, however, shows this not to be the case, the loss in illuminating value being as great as with the carbon monoxide alone.

Illuminating value of the original oil gas.... 54.7 candles.

Percentage of Water Gas.	Percentage of Oil Gas.	Illuminating Value of the Mixture. Found.	Calculated.
90	10	unreadable	5.4
75	25	11.9	13.6
50	50	21.6	27.3
25	75	35.6	41.0

These experiments not only show the fallacy of supposing it is possible to calculate the amount of enriching gas which it is necessary to add in order to attain a given illuminating value, without first taking into consideration the composition of the gas to be enriched, but also furnish interesting information on the important subject of carbureting non-luminous gases.

The varying effect exercised upon enriching gases by the different diluents is not due to one cause only, but to several acting in unison. In the first place, the illuminating power of a flame is, to a great extent, governed by temperature. The hotter the flame, the more readily are the hydrocarbons broken down and the carbon liberated; and the light which this emits being entirely governed by temperature, the hottest flame will always yield the most light from any given quantity of hydrocarbons. If we take two flames of equal size, the one obtained by burning hydrogen, and the other carbon monoxide, it will always be found that the former is the hotter. Taking a jet of hydrogen 3 inches in height, and a similar one of carbon monoxide, and testing their temperature with a Le Chatelier thermo-couple, the hydrogen flame was found to have a temperature of 1,488° C. (2,610° F.); while a carbon monoxide flame of the same size gave a temperature of 1,419° C. (2,554° F.). Another cause, however, I think is to be found in the fact that, as a carbureted carbon monoxide flame burns, a large proportion of carbon dioxide is produced and drawn into the flame; and this in the luminous zone of the flame attacks the liberated carbon, combining with it to form carbon monoxide again, and so uses up some of the carbon upon the presence of which luminosity depends, while the high specific heat of the carbon dioxide tends to cool the flame. The cause of the increased effect produced by enrichment upon a poor coal gas is to a great extent the methane, which forms a very large proportion of the saturated hydrocarbons, and which, although it is practically non-luminous when burnt alone, adds considerably to the luminosity of the mixture; also to the hydrogen, more than 50 per cent. of which is present, and which increases the temperature, and by so doing the luminosity likewise, while carbon monoxide is only present in coal gas in quantities varying from 3 to 8 per cent., so that its effect upon the luminosity of the flame is entirely overshadowed by the increase due to hydrogen and methane.

The last class of the constituents of coal gas—*i. e.*, the impurities—will be dealt with under the subject of "Purification."

The constituents of an illuminating gas have a very great influence upon the size of a coal gas flame. Both hydrogen and carbon monoxide burn with an extremely short flame, as they only require one-half their own volume of oxygen for their complete combustion, and are able to obtain this with a very short travel from the burner; while methane, requiring twice its volume of oxygen, burns with a flame nearly four times the height, if consumed at the same rate of flow. The percentage of ethylene, ethane and benzine in coal gas is so small that they can can do but little towards increasing the size of the flame, although, when pure ethylene or ethane is burnt alone, it would not be possible to consume it in an ordinary burner at the rate of 5 cubic feet per hour. Using the "London" argand, as employed for gas testing, it would not be possible to burn much more than 2 cubic feet of pure ethylene or ethane per hour without the flame smoking. Using ordinary 16-candle London coal gas enriched by cannel, it may be roughly stated to yield a 3 inch flame in the "London" argand; the height of the flame being due to methane, of which such gas contains about 35 to 40 per cent. If, however, carbureted water gas is taken, I have frequently seen a 2-inch flame emitting light equal to 22 candles illuminating value; this being due to its only containing 16 to 20 per cent. of methane.

Published analyses of carbureted water gas are mostly misleading, as this gas, when made by generating the water gas and then passing it through superheaters in which oil is being decomposed, always contains higher members of the methane series, which, on explosion with oxygen during the analysis of the gas, yield considerable volumes of carbon dioxide, which is calculated as coming from the methane, with the result that this gas is shown too high in the analysis—the hydrogen being low in proportion.

Transport of Petroleum in Bulk.

[Abstracted from a paper by Mr. Boverton Redwood, before the British Institution of Civil Engineers.]

Beginning with the question of accidents arising from transport in bulk, the author stated that the few, but unfortunately serious, disasters which had attended the general adoption of the system of transporting petroleum in bulk in tank steamships had been collectively of a most instructive character, and there was much to be gained by a critical consideration of the conditions under which they arose. Before, however, proceeding to review these, reference was made to some cases of accident not connected with this mode of transport, or in which other volatile inflammable liquids had been implicated. Many explosions and fires described had resulted from the incautious use of naked lights and fires on small vessels carrying petroleum spirit—the Regent's Park explosion affording an illustration of the danger thus created. Cases were also recorded in which the ignition of an inflammable or explosive mixture of vapor and air in benzoline stores on manufacturing premises, in public sewers, and elsewhere, had been attended by more or less disastrous consequences; and particulars were given of accidents of a similar character with carbon disulphide, methylated spirit and whisky.

Details were furnished of the principal accidents which had taken place in connection with the transport of petroleum in bulk. In the case of the steamship Petriana, it was shown that there was no audible explosion, but a silent ignition of oil which had escaped in a state of spray into an empty compartment. In the instances of the steamship Ville de Calais, steamship Fergusons, steamship Tancarville, and steamship Petrolea, there was a violent explosion. The loss of the steamship Lux was primarily due to the ignition of oil which had gained access to the boiler space. With the exception of the first and last, these vessels carried crude petroleum, while in the two exceptional cases the cargo consisted of refined petroleum (kerosene).

The formation and ignition of inflammable and explosive mixtures of petroleum vapor and air were next considered, the author stating that certain descriptions of petroleum evaporated freely at common temperatures; that the vapor given off was much heavier than air, and might remain for a considerable length of time in any receptacle capable of holding a liquid, or might flow unperceived for some distance in a stream similar to that of liquid; that the vapor was highly inflammable, and capable of carrying back flame to the source whence it emanated; and that mixtures of petroleum vapor and air might be either inflammable (burning silently) or more or less violently explosive. It was further shown that petroleum, at temperatures below that at which vapor was freely evolved, might be converted into a highly combustible spray. Crude petroleum consisted of a great number of hydrocarbons, some of which were exceedingly volatile, and the vapor given off might be from 2½ to 3½ times heavier than air, its density depending upon the chemical composition of the hydrocarbons present. From the vapor density the volume of vapor given might be calculated, and it was thus found that one volume of a petroleum spirit, consisting principally of hexane, yielded 187 volumes of vapor at 60° F. The percentage volume of the vapor of a volatile hydrocarbon taken up by air depended upon the tension of the vapor, and varied with the temperature. When the vapor of petroleum was brought into contact with air, diffusion took place, the heavy vapor traveling upwards into the lighter air, and the air passing downwards into the vapor. The weight of a volatile liquid hydrocarbon which would pass into a given volume of air (up to the point of saturation), was the same as that which would volatilize into an equal vacuous space, though the evaporation into air took place far more slowly than into a vacuum, and when the air became saturated with vapor, the tension of the mixture was the sum of the tensions of the air and vapor separately. Therefore, when petroleum spirit or crude petroleum was evaporating in a partially filled tank, a large increase in the volume of the atmosphere above the liquid in the tank took place. The proportions of vapor and air requisite for the production of inflammable and explosive mixtures were experimentally determined with apparatus described, and the data obtained were set forth in the paper. The general principles governing the manner in which such mixtures behaved on ignition were also discussed. Briefly, it was found that when a volatile hydrocarbon was evaporating into air in a confined space, the atmosphere first became inflammable (burning slightly), then more and more explosive up to a certain point, then less and less explosive, and finally (if sufficient hydrocarbon were present in the atmosphere) only combustible when in contact with the outer air. The conditions under which an explosive mixture of petroleum vapor and air might be ignited were investigated, and it was stated that neither the glowing end of an ordinary wooden match or of a "fixed star" vesuvian, the flame of which had been extinguished, nor a red-hot coal which had ceased to blaze, nor a shower of sparks from a flint and steel or from the fireworks known as "scintillettes" and "golden rain," was capable of causing the combustion of the mixture; but a platinum wire raised to white heat by means of electricity invariably caused ignition, though at a red heat no such effect was produced. Either the electric spark or a flame at once caused the explosion of such a mixture, but an inflammable mixture containing a small proportion of vapor might be ignited by a large flame, when a small flame or an electric spark proved ineffective for the purpose. The use in an oil tank of a heated rivet at a temperature below that which was requisite for the ignition of a mixture of petroleum vapor and air might nevertheless be attended with danger, owing to the ignition of the oil which remained between the plates at the laps. Particulars were given of instances of the ignition of benzoline vapor by the discharge of electricity accidentally brought about in the industrial use of the liquid for "dry cleaning," etc.

The subject of the construction of petroleum tank steamers was next referred to, and mention made of papers read before other bodies. There were, however, a few points arising out of the accidents referred to still undealt with. The importance of extending to the extreme height of the upper deck the cofferdams separating the oil tanks from other spaces had now become recognized, and if there were any doorways in the 'tween decks, in the bulkheads forming the cofferdam, adjoining the engine space, they should be fitted with doors which could be screwed up oil tight. There was now a general consensus of opinion in favor of keeping the cofferdam full of water while the vessel had her cargo of oil on board. The oil tanks should be completely isolated from the cofferdams and other spaces, and should, therefore, be fitted with a separate service of pipes and pumps. In steamships carrying volatile crude petroleum in bulk there should be provision for the safe discharge of vapor from the tanks, and tank steamships in general should be fitted with steam jet or fan ventilating appliances.

The precautions to be observed in the management of tank steamships were next considered. So long as the cargo tanks of a properly constructed tank steamship were full of oil, there was very little risk of fire or explosion, except through serious structural damage resulting from collision or other accident. The accumulation of vapor in the 'tween-deck bunkers, due to leakage of oil from the expansion trunks of the oil tanks, must, however, be guarded against, and care must be taken that the expansion trunks did not become overfilled or empty in consequence of increase or diminution in the volume of the oil. Even in the case of vessels carrying crude petroleum in bulk there would not be sufficient justification for any attempt to prevent smoking and the use of matches while at sea, but it was desirable that special places should be set apart for smoking, and that only safety matches should be used; both smoking and the use or carrying of matches elsewhere being strictly prohibited. The chief risk occurred during loading and discharging. At such times, therefore, smoking and the use or carrying of matches of any kind anywhere on board, as well as the employment of naked lights and fires (other than the main boiler fires, which should be banked), should be rigorously prohibited. The vessel should, except as regards the necessary marine lights, be lighted only by electric glow lamps, the ship being carefully wired, the positions of the switchboards being judiciously chosen, and any lamps used in spaces liable to become charged with vapor being of safe construction. The tank covers should be kept closed as much as possible, and in the case of crude petroleum, provision must be made for the safe discharge of vapor during loading or while water ballast was being taken in. Before the tanks were entered for inspection they should be ventilated, and if repairs necessitating the use of hot rivets were to be effected, the oil compartments and adjacent spaces should be thoroughly cleansed and efficiently ventilated in the manner described in the paper, until on testing by a competent expert the complete removal of inflammable vapor was found to have been accomplished.

The paper concluded with some remarks on testing the atmosphere of tanks and other spaces. This subject had engaged the attention of the author during the past two years and a half, and details of his experiments were given. The author had experimented with apparatus for collecting and testing samples of the atmosphere of oil tanks and other spaces. The test lamp employed, in common with the miner's lamp referred to, depended for its action upon the formation of a "cap" over the hydrogen flame, and it was found that this "cap" was distinctly visible when air containing considerably less than the proportion of vapor necessary for the formation of even an inflammable mixture, and still less than that requisite to produce an explosion, was tested. The apparatus, the construction and mode of use of which were fully described, had been practically employed, and had given satisfactory re-

sults. A delicate form of manometer which had been successfully applied to the determination of the proportion of petroleum vapor in air, was also described. The action of this instrument was due to the increase in density of air containing the vapor of hydrocarbons.

Notes on the Designing of Metallic Structures.

By Mr. O. J. Marstrand.

The actual work of designing may, for the purpose of analysis, be considered under the following subheads, viz.: Calculation of Stresses, Draughting, Estimating and the Writing of Specifications. In the following a few practical suggestions will be offered as to the manner of executing such work, considering first each division separately, and later taking a general view of the subject.

Calculation of Stresses.—In all calculations it is a good rule to perform similar operations at the same time. If, for instance, we are calculating a series of girders under loads varying in intensity and position, it will save considerable time, and tend to lessen the chances for error, if we draw first the different open lengths, then indicate the various loads throughout, then find all the reactions, then all the moments, etc., etc. It is unnecessary here to dwell much upon the value of graphical method in calculating, such being now so universally used. A graphical solution frequently commends itself as a short cut, and as a practical example thereof may be mentioned the determining of the lengths of cover plates in girders, which becomes a very simple matter when ordinates representing the chord sections at different points are erected on the line of the top chord, and their ends united. We then have before us the sections to provide for, and can put in one, two or more lines parallel to the top chord, and representing the section of the angles and one or more covers, in such a manner as to secure least waste of material. As a check on one's own arithmetical work graphical construction is also of great use. It is frequently employed exclu sively, and the writer believes that besides its mere mechanical advantages it is by far a more healthful manner for the brain to work in than the fatiguing processes of constant figuring, which in the steady and long run must develop the brain so specifically that its general usefulness is impaired.

In regard to the degree of accuracy in calculations, it may be laid down as a general principle that any refinement which is not warranted by the premises nor by the nature of the problem should not be indulged in. The familiar example of pacing off the diameter of a circle, and then calculating its area to decimal places, should be borne in mind. Again, the uselessness of calculating a railroad bridge for certain given wheel concentrations, when these loads are known to be variable both in amount and in effect, and engines themselves are constantly changing on the same line, is now quite generally recognized. While, of course, all work should be on the side of safety, the calculator should cultivate his mind to take that general view of a problem which will bring out its nature and object in such a manner that he is enabled to make his work a homogeneous part of the whole.

Draughting.—The plans to be made are either general or detail drawings. Among the latter the writer will distinguish between two kinds —viz., working drawings and shop drawings. By working drawings he means such as will control in every essential detail the making of the necessary shop drawings without being intended for shop use. In his opinion, it is the best practice for the engineering company to fur nish the contractor with such working drawings from which the contractor is himself expected to prepare his own shop drawings, according to his own conventional office and shop rules, and submit these for the approval of the engineer. Considerable time is gained in the engineer's office by not attempting to make drawings which a contractor can use in his shop; and it is believed that the contractor is also served by this method, as it probably is as expeditious for him to prepare shop drawings from working drawings as it would be to scrutinize them carefully as to whether they conform to his conventional practice or not, and then eventually have to change them. For that the contractor has conventional methods, in the use of which his men are trained and experienced, is taken for granted; and in these methods the engineer has no interest, except, indeed, to recognize them and interfere with them as little as possible. The number of working drawings needed is of course much smaller than that of shop drawings; a good many things can be covered by the use of working drawings and tables of data which would have to be specially drawn out for the shop. Besides, it is well that the drawings can be checked by other hands while being transposed in the contractor's office.

The principal requirements in structural draughting are accuracy as to figures and dispatch. As an incentive to produce the best results at the draughting board the writer would advise to lay out work a little ahead; for instance, during the last five or ten minutes of the day lay out the amount of work to be performed on the next. Draughting easily becomes monotonous, and it is a great assistance to have prepared a standard of one's own to keep up to.

Most offices use sheets of standard size, which is much to be preferred; it is also customary that a certain scale, as that of 1 inch to the foot or ¼ inch to the foot, prevails in the office. It is therefore necessary to estimate in advance how much one can place on the sheet and how to place it.

Before drawing a single piece like a column or a girder, or any member of a truss, sketches of all connections thereto should be made, so that these details are first decided upon. This may save a considerable amount of rubbing out and changing. On the whole, it is of importance, before starting the work, to go over it in a general way, noting the number of different pieces, and those that are of the same kind, and can be shown by reference to one drawing. In working drawings the accuracy of the scale is of no importance; everything should be given by figures, and the workman is expected to go by them only.

In determining upon dimensions, both general and detail, it is necessary to see that there is sufficient clearance, that is, that passengers, cars, loaded teams, etc., may, in their regular course, pass by unobstructed; in buildings, too, one must provide access for light and air, as well as proper drainage for water. In such places where water would be likely to accumulate, as at the bases of exposed columns, the sections should be re enforced against corrosion and provision made to shed this water as rapidly as possible.

In placing rivets care should be taken that it is possible to drive them; it may be necessary in some places to use bolts, but rivets are preferred, and it is for the draughtsman to see that they are so placed that the tools can be applied.

Care should also be taken that all parts are as much as possible accessible to painting after being assembled.

Estimating.—In estimating weights and cost it is customary to classify the subject in groups according to the various members of the structure, as columns, girders, top chords, bars, etc., etc. Each group should then again be subdivided according to the shapes used, into angles, channels, beams, plates, etc., the reason being that these shapes vary in price. As to the degree of accuracy in calculating, it is considered sufficient to take the figures for the weight per foot and the length in feet, with one decimal each, and give the result without decimals. These values are given in the many useful pocket companions issued by the iron and steel manufacturers. Such books are of the greatest value to the calculator, draughtsman, and estimator; they contain a great amount of special information needed in their work. In estimating it is advisable to place the number of pieces, weight per foot, and length in feet in the three last columns, in order to have the figures that are to be multiplied next to each other. The rule mentioned above, to perform similar operations at the same time, is a very useful one here; thus, to begin by classifying, then write down all the different shapes and number of pieces, then their lengths, then all weights per foot, and finally perform the multiplications and get the totals. On the basis of these quantities the cost of the work is then estimated.

Specifications.—This subject is only mentioned here as constituting part of the designer's work, and that of a very high order. The writer does not feel that he has sufficient knowledge of his own on this subject to offer any suggestions, but he recalls a lecture on specifications recently delivered by Mr. Theodore Cooper, and takes the liberty to refer to that for information. The subjects that have here been lightly touched upon constitute the component parts of the practical work of designing, or rather the expression of that which is itself the most important part of the work—the thought that has conceived and developed it. A designer should endeavor to so arrange his time that he provides room for thinking; to be sure, our best thoughts do not as a rule occur to us at certain prearranged hours of the day; they are often snatched at odd times, in railroad cars, when listening to discourses in societies, or during the leisure hours at home. But to the writer it is a question if not, on the whole, the best results would be obtained by systematizing also this part of our work, and the physiologists tell us that it is work of the hardest kind. While riding in a railroad car the time may undoubtedly be advantageously spent in this way and could be so assigned. The time during office hours is, however, not a good one for work that requires much thought, as interruptions cannot usually be avoided, and it is therefore not an easy matter to provide for it and at the same time find room for rest and recreation. But the subject is of the greatest importance, and the only way in which it can be controlled is to treat

this work of thought in the same systematic manner as we treat our other duties.

The amount of thinking must of course always be largely in excess of the visible products thereof. One of the greatest results to be obtained is simplicity; that simplicity which combines form and purpose in such a manner that we rejoice in contemplating it. A popular author once said, that certain of his passages which appeared to flow most easily and beautifully from his pen had still given him the greatest amount of thought work in order to shape them so that they might appear not to have caused any labor at all. This frank statement undoubtedly appeals to every designer as being his own experience as well. The most satisfactory results have been obtained by this concentrated and persevering effort of thought, which therefore becomes indeed the chief instrument of the designer.

In conclusion, the designer must be experienced in calculating, draughting and estimating; he ought himself personally to have done a considerable share of each kind—they are the posts in the future structure. At the same time "with his feet on the ground and his eyes on the ball" it is through study, observation, and inspection of work under construction, maintenance and operation; through a systematic perusal of technical publications and through association with fellow-engineers in our various societies that he must qualify himself for the work of designing. Serious mistakes in the designing of railroad structures are made through lack of knowledge or proper regard for the requirements of maintenance and operation; and indeed many designers are largely affected by conditions which, in a certain sense, perhaps, are not professional, although engineering in its highest sense is a profession so broad that study and observation cannot be made too general.

Some Points of Consideration in the Choice of an Engine.

[A paper read by Mr. J. S. Stephens, of St. Paul, Minn., before the Northwestern Electrical Association.]

The number and variety of different engines made in this country and advertised as especially adapted to the driving of electrical machinery is great enough to meet the requirements of the majority of purchasers, and usually more than sufficient for the man who undertakes to sell any one of the different types or different qualities of kind which are manufactured. In a paper under the above heading a description of the different types of engine will of course be in order. As to difference in quality of kind, a feeling somewhat of a mixture of modesty on the part of the author and justice to his competitors, who, like himself, make a business of selling engines, but are not represented here, prevents him from going far into description of detail, although the present opportunity to tell you how many good points there are in construction of the particular engine he represents is certainly a very tempting one, but the absence of the other fellow to tell you how much better his engine is, or to tell you something about the "Russell" engine that the author of this might possibly forget to tell you, will, he is sorry to say, prevent. The purchase of an engine is too often made upon the assertion or guarantee of the maker or his representative, or upon the recommendation of some friend who has one of a particular kind of engine in use that has given him good satisfaction, notwithstanding the fact that there may be a dozen better built and more economical engines which this friend has never used and very likely has never seen. This matter of guarantee is often misleading, especially in the installation of an engine for electric service where the conditions usually imposed in such guarantees are practically impossible of attainment under ordinary conditions, or if such a test were made as would establish beyond a doubt that the guaranteed efficiency had been complied with, the cost of such a test would be prohibitive, the contract nine times out of ten not providing for any method of proof of fulfilment of guarantee, or designating who shall make or provide for expense of tests required.

It is the author's opinion that much better results would accrue to benefit of purchaser if he first of all thoroughly studied the different types of engine construction and the possibilities of these different types from a mechanical standpoint, deciding for himself, aided by what disinterested advice he may be able to obtain, taking into consideration the items of fuel, present size and probable growth of plant, probable variations in load, cost of attendance or maintenance, cost of water supply for condensing, and interest and depreciation on first cost of engine, condenser piping and foundations.

The product of a proper valuation of the above items, as applied to plant in question, based on a knowledge of the real possibilities of the different types of engines, as viewed from a mechanical standpoint, should determine type of engine to be used.

To draw some line of distinction between different types so as to enable the prospective purchaser to make a fair start, and if possible to prevent to some extent the misunderstanding caused by the submitting of proposals, all on the same basis of economy, and service for engines that are radically different in construction, is the aim of this paper, that a want of knowledge of the real economical and constructive difference is plainly evident; the maker of the higher grade of engine placed at a disadvantage and the customer often suffers the real loss by getting an engine not as economical as he had expected has too often been demonstrated. It is quite common to hear the assertion made that the single valve, usually designated high speed engine, is just as economical in steam consumption as one of the 4-valve type, generally designated slow speed, Corliss, Russell, Green, Wheelock and others of this class, or we may have a 2-valve engine (of which the "Buckeye" and "Williams" are perhaps representative) talked at us as being superior to the single valve construction, which it undoubtedly is, but the matter is often carried farther, and the assertion made that it is also just as good or better than a 4-valve engine, to which we object.

For the present, and in a paper as short as it is necessary to make this one, a broad division of these types of the different engines offered to the trade will be made as follows: 1st, the single valve engine; 2nd, the double valve engine; 3d, the 4-valve engine. A further subdivision or addition to the above would perhaps be advisable, but it is feared would make the whole matter too long drawn out. A description then of these three types, their advantages and disadvantages, each as a particular type, is all that will be attempted.

All these remarks, you will understand, refer to automatic cut-off engines, from the simplest piston valve engine up to the most complicated 4-valve Corliss. In the single valve engine the steam admission, cut-off and exhaust opening and closure are all accomplished by the simple reciprocating movement of one valve; the point of cut-off must of necessity be variable to accommodate the power of the engine to a varying load or steam pressure. To accomplish this means that every time the point of cut off varies the point of opening and closure of exhaust part will also vary, a feature that necessitates in all such engines a very large proportion of clearance space, so as to as far as possible prevent too great a variation in compression, sacrificing the economy of the engine to the necessities of mechanical construction. The theoretically perfect engine would have no clearance whatever, allowing the necessity of sufficient compression to cushion or properly balance the moving weight of the reciprocating parts of an engine. Such compression should be a fixed proportion in each engine for a given weight of parts and stated speed. It varies with a varying load and cut-off; it will, except at only one point of cut off, be too little or too much, or a change in speed of the engine from that at which it was originally designed to run will change the point of cut-off at which the quantity of compression will be right for most economical results. To summarize, the limited possibilities of positive adjustment to meet varying requirements of service, and the constant changing of exhaust opening and closure under change of load or steam pressure, in itself works greatly against the economy of the engine and requires such sacrifices in design as to make anything approximating the highest economy impossible.

The double, or 2-valve engine can do better, or perhaps it will be best to say that more can be done with it. The valve arrangement usually consists of a main valve having a fixed travel, admitting and exhausting the steam from the cylinder at the same point under all working conditions, the variable automatic cut-off being accomplished by an independent or second valve; in this engine we have the advantage of a fixed compression which is, as it were, part of the engine, and may be designed to be just right for that particular engine at a particular speed. It will at least allow of a design of cylinder with much less clearance or waste room than is possible or advisable in the single valve construction. The cut-off of this style of engine may be as good as the best, this function of any engine only varying in the degree that its design of valve and connections will allow of closing the greatest area of part in the shortest possible time relative to the cylinder area and speed of piston. The disadvantages of the 2-valve construction are, however, more than enough, providing the amount of compression has been designed to be just as it should be for a certain speed; a change in speed of this engine so as to accommodate a certain, or average load, to the most economical point of cut-off, or an increase of original speed of engine for an increase of power, will leave you with too little or too much compression for best results at such speed, and no chance to adjust exhaust to meet requirements; for any change of point of exhaust opening and closure will change point of admission of steam to cylinder, or *vice versa*, and neither the admission nor exhaust can be changed on one end of cylinder without at the same time affecting the adjustment of all

the other functions of admission and exhaust. Another great disadvantage of this construction is the necessity of passing the live and exhaust steam through the same valve and ports, the exhaust always being of much lower temperature than the other, and of necessity carrying away considerable of the heat value of the live steam with it; this is especially noticeable when such engines are non condensing, and the boiler pressure and exhaust pressure with this type of valve only being separated from each other by the working face of the valve, a chance for a leak, that is often considerable, occurs at this point, *and all valves leak more or less at times.* What can be said of a 4-valve engine in comparison with these? Should any comparison be made, or should each of these three be allowed to compete all on the same basis, as is often the case?

The author does not believe that any of the different styles of 4-valve type of engine, as at present built, are perfection, yet to prevent reiteration, less cannot be said than that the 4 valve engine has all the advantages of range of adjustment to obtain the greatest economy under varying conditions of service, that it has been claimed the single and double valve engines have not. Each feature, steam admission, cut-off and exhaust, can be independently adjusted. The clearance may be the minimum. The chances of loss from leakage of valves and loss from transfer of heat from live to exhaust steam will be lessened, in fact it hardly seems reasonable to expect the same results from the standpoint of steam economy from each of these three types of engines. In general there is fully as much difference in different styles or makes of these different types as there is difference in types. These points are in detail, many of which details may be applied to the different types irrespectively. Like most else, where we have a choice, the good, bad and indifferent may be had. It is only hoped by the author that he has made his subject clear enough to be of some little value to those present who have so kindly favored him with their attention. He also hopes that should any of the gentlemen present at any time in the future consider the purchase of an engine, they will first decide on the type of engine they want, and then look well to detail.

Oil Fuel.

The *Scientific American* says that an interesting report on the results of using oil fuel at the Chicago Exhibition has been presented to the Standard Oil Company by Mr. Charles F. Foster. This statement avers that the use of oil as fuel has been entirely satisfactory in every particular. During the period the Exhibition remained open the main boiler plant consumed 10,614,401 gallons, or 74,300,805 pounds of oil for generating steam, developing the aggregate energy of 32,315,964-horse power hours, at a cost of 6.3 mills per horse power hour. The contract price for the oil delivered in the Exhibition tanks was 72½ cents per barrel of 42 United States standard gallons. The boiler house force and equipment comprised 210 burners, atomizing oil beneath 52 boilers with a standard rating of about 21,100 horse power, and attended by a staff of 42 men divided into three 8 hour shifts. The saving in cost of both fuel and labor for the oil fuel, as compared with coal of fair quality at market price for large quantities, is apparent. An equivalent consumption of from 500 to 600 tons of coal per day would have been necessary, so that for the duration of the Exhibition 70,000 tons of coal would have been needed; and Mr. Foster remarks that "it would be difficult to imagine how this vast amount of coal would, in the limited space available, have been handled expeditiously and without endangering life and property." The saving to the Exhibition by the use of oil fuel was about 27 per cent. as compared with the estimated cost of coal, including the labor of handling. The oil plant worked from start to finish without a break; and the smokelessness and absence of odor from the chimneys of the boiler house were made a subject of general comment.

Dr. Carl Otto Weber states that in the use of liquid fuel Russia appeared to be in advance of all other countries. During the coal strike many Manchester firms had recourse to petroleum as a fuel, but the results in every instance seemed to have been discouraging. In Russia it was only the heavy petroleum residues (astatki) which were used for boilers, railway engines and similar purposes. Astatki on combustion produced 11,000 cal. as against about 8,000 cal. obtained from first-class steam coal. It appeared, therefore, that in this respect 62 pounds of astatki were equal to 100 pounds of coal. By working side by side two boilers of the same type, firing the one with coal, the other with astatki, it was found that 1 pound of coal evaporated 8 pounds of water, and 1 pound of astatki 13 pounds of water. The relation between the volume of air passing into the furnace and the quantity of water evaporated was also important; and it was found that for 1,000 cubic feet of air consumed, coal evaporates 1.5 and astatki 2 pounds of water. Consequently, besides a smaller weight of fuel, also about 20 per cent. less heating surface was required for astatki fires. This was apart from the cost of the fuel, an item of considerable importance for marine boilers, as it would allow to reduce their volume very considerably without lessening their steam-producing capacity.

The works in and around Moscow used in 1890 about 100,000 tons of astatki at a saving of about 30 per cent. as compared with coal. The price of the residue at Moscow is $25 per ton; at Baku no more than $2.50.

The Use of Electrolysis in Technical Chemical Processes.

By Mr. J. W. Langley.

Technical chemistry covers a very wide field, stretching from metallurgy on one side to the production of the most delicate colors and odors on the other, in all of which, possibly, electricity is destined to play a part, although up to the present time it has only been used to any important extent in the division including the chemical side of metallurgy. Here by far the most notable examples of its use are in the purification of copper and in the extraction of aluminum.

The electrolytic separation of pure copper from crude copper is substantially only a large expansion of the old processes of electrotyping and electroplating, and therefore does not offer much which is novel; but the production of aluminum from its oxide is a typical example of an electro-metallurgical operation. I propose, therefore, to describe somewhat in detail the method employed, as it will serve to indicate the steps and precautions to be observed in the applications of electrolysis to other metallic compounds.

The electrolytic production of aluminum is an industry only five years old, but in that short period it has completely revolutionized the manufacture of this metal; indeed it is to day the only successful method, and will probably remain for a long time without a competitor. In this country the process is carried on only by the Pittsburgh Reduction Company, at New Kensington, Pa., which manufactures under broad patents granted to Chas. M. Hall, the discoverer and patentee of what is now generally known as the Hall process.

The very important discovery which is the foundation of this method is the fact that oxide of aluminum is soluble in certain double fluorides in a fused condition. The salt which operates the best for this purpose must be composed of fluoride of aluminum and of a fluoride of a base more electro-positive than aluminum; sodium, potassium, and lithium fulfill this condition, but on account of expense fluoride of sodium is preferred. The mineral cryolite $Al_2Na_6F_{12}$, or, as it may also be written, $Al_2F_6(NaF)_6$, is a native fluoride coming within the requirements of the class of double fluorides necessary, and it forms the principal solvent used. Only, as its melting point is somewhat high, it is an advantage when not operating on a very large scale to add to it small amounts of other fluorides to bring down the fusing point.

Cryolite will dissolve more than 25 per cent. of its weight of alumina forming a clear and colorless solution from which the metal can be readily electrolyzed.

There are some features of theoretical interest about this act of solution, for that it is a solution rather than a chemical compound there can be no doubt. Alumina when added to the melted salt dissolves quietly without effervescence or any manifest evolution of heat, resembling in all respects the solution of salt or sugar in water. But alumina is not appreciably soluble in melted sodium fluoride, and aluminum fluoride by itself is infusible except at extremely high temperatures. The presence of both fluorides is absolutely essential. The two fluorides may be taken initially as a double salt, or they may be separately mixed with alumina; the final result is the same—viz., the perfect solution of the oxide.

The electrolytic decomposition of the dissolved oxide is carried out on a manufacturing scale by using carbon electrodes. A rectangular vessel made of iron boiler plate is lined with compressed carbon to a thickness of from 4 to 6 inches. This constitutes the negative electrode; the positive electrode is formed of carbon rods 3 inches in diameter by 12 in length, suspended by copper rods from a horizontal copper arm above the iron vessel. The number and disposition of these copper anodes depends on the scale of the operation. They are hung so that they will terminate about one inch from the carbon lining, and the purpose of suspending them is that they may be easily removable one or two at a time without stopping the whole current going through the apparatus. The iron vessel is called the pot. The melted cryolite, the bath; or, when it holds alumina in solution, is often termed the electrolyte.

To start the operation some powdered cryolite or the mixture of double

fluorides is placed on the carbon lining, which is cold. The carbon anodes are then lowered till they make contact with the lining, much local heat being at once produced partly by the resistance of the carbon at the points of contact and partly by numerous short arcs formed where apposition is not perfect. This heat soon melts some of the bath material, which, flowing between the electrodes, adds its own resistance, thereby increasing the heat because there is now a larger cross section of conductor and consequently more current carried. In this way the bath material is fused and the pot finally filled. The pot may also be initially charged with melted cryolite ladled into it from a separate melting pot.

During the period while the bath mixture is fusing, electrolysis is necessarily going on, but it yields only a small quantity of aluminum, probably because of the access of the air and also because any fluorine, potentially or actually liberated, finds some of the metal in a finely divided and diffused condition, with which it reunites.

When a sufficient volume of melted bath is secured the second or permanent stage of manufacture begins; powdered alumina is spread over the top of the bath and periodically stirred down into it. It dissolves almost immediately and normal electrolysis takes place. Aluminum is deposited in a melted condition at the bottom of the bath against the negative electrode, while the oxygen which is transferred to the positive side burns the anodes escaping as carbon monoxide and carbon dioxide. The anodes are thus consumed and must be from time to time pushed down further into the bath. The melted fluorides are not electrolyzed and may be used over and over again indefinitely, it being only necessary to add enough to supply the small losses, principally of a mechanical nature, occasioned by the removal of the metal. The operation is strictly continuous. Alumina is added on the top of the bath and the metal is ladled out from the bottom.

There is quite a complicated adjustment of chemical and electrical forces concerned in the successful electrolysis of alumina, which are interesting from the standpoint of pure science.

The current employed by the Pittsburgh Reduction Company is 7,000 amperes. In order to send this through a bath of melted fluorides only, with the usual current density, requires 15 volts; but as soon as alumina is added the pressure promptly falls to from 6 to 7 volts, which is that necessary for the normal working of the process. This E. M. F. is obviously consumed in two ways: First, by the force of polarization necessary to break up a molecule of Al_2O_3; second, by the fall of potential due to the resistance of the anodes and of the bath. It is possible to calculate this work both in chemical and in electrical measures.

The heat of formation of one molecule each of the bath constituents is as follows:

Sodium fluoride	109,700 calories.
Aluminum fluoride	550,000 "
Aluminum oxide	388,920 "

The electromotive force of decomposition depends, as is well known, on the equivalent and not on the molecular weight, and these will be $Al_2O_3 = Al_2F_6 = 6$ (NaF.)

The energy of 22,900 calories is proportional to 1 volt, according to Sir William Thomson; therefore the E. M. F. of decomposition will be:

Sodium fluoride	$\frac{109700}{22900} = 4.8$ volts.
Aluminum fluoride	$\frac{550000}{22900 \times 6} = 4.0$ volts.
Aluminum oxide	$\frac{388920}{22900 \times 6} = 2.8$ volts.

Thus the oxide of aluminum is the weakest body present and the only one to be decomposed, provided the current density is not permitted to become too great.

The fact that no appreciable quantity of fluorine is given off, but only oxygen, when the pots are working at normal voltage and current, is perfectly explained by the above theoretical values of the electromotive force of decomposition. The direct measurement of this force presents considerable difficulty on account of the variation of the resistance of the bath with its temperature, but the best estimates from actual measures show that the breaking stress of one sixth of a molecule of alumina is certainly less than 3.5 volts. Thus the theoretical number is fairly well sustained by practical observation.

The fundamental conditions for the successful electrolysis of any metallic compound are then these: First, the metallic salt must be in the fluid state; second, if it is rendered fluid by a solvent then the electromotive force of decomposition of the salt must be less than that of the solvent; third, the current density must be carefully regulated. These statements apply equally to aqueous solutions and to baths rendered fluid by fusion. The double fluorides would seem to be the only substances which can fulfill these conditions on a commercial scale for aluminum.

The theoretical equation of the decomposition of alumina by carbon is—

$$Al_2O_3 + 3C = 2Al + 3CO$$

which would require about two thirds of a pound of carbon for each pound of metal produced. Now, in the electrolytic process one pound of carbon anodes is lost for each pound of metal, the slight excess over theory being due to some combustion of the carbon by the air above the surface of the bath. The yield of metal is one pound of aluminum for 18.1 electrical horse power hours. This energy, it must be remembered, is spent both in causing decomposition and in maintaining the temperature of the bath, which is about that of the melting point of copper.

Taking the voltage of the baths as 7, then 18.1 electrical horse power hours represent a continuous flow of 1,926 amperes for one hour. This would theoretically deposit 1.43 pounds of aluminum, so that the actual yield is 70 per cent. of the theoretical ampere production. This must be considered fairly satisfactory. Of course the yield calculated on the total energy consumed is considerably less than this, owing to the large fraction which is turned into heat; but this loss must be set over against the consumption of fuel in ordinary metallurgical work where it is burned solely to produce heat.

Another example of the application of electrolysis to an important industry is the refining of gold and silver, but more particularly silver. The practical details as carried out by the Pennsylvania Lead Company, of Pittsburgh, Pa., under the Moebius process are as follows:

Tanks are made and divided into compartments so that they may be connected up in series. The unit compartment is 18 × 24 × 17 inches deep, and 70 of these are in the circuit at one time. Each compartment has three anodes, 10 × 20 × ½ inches, and four cathodes of about the same area as the anodes. The anodes are composed of the metal to be refined, which will average 990 fine in silver, the rest being mainly copper, lead, bismuth with a little gold. The cathodes are thin sheets of pure silver. The surface exposed in each compartment, reckoning both sides of the plates, is 20 square feet, or 1,400 feet for all the tanks. The anodes are hung in a bag to catch the insoluble material which drops from them. The electrolyte is a dilute nitric acid as free as possible from sulphuric acid or chlorine. A current of 180 amperes is used, and the voltage required by each compartment is 1½ volts. The consumption of nitric acid (36° B.) is about 2 pounds per day for each compartment. The amount of silver deposited is, in practice, about 470 ounces per 24 hours in each compartment, which is equal to 1.35 pounds avoirdupois per hour. This includes all interruptions of current for all reasons. The total amount of silver refined per day is 32,900 ounces, or practically 1 ton. This is 84 per cent. of the theoretical yield for 180 amperes working the same length of time without any interruption whatever. The product is practically silver 1,000 fine.

The success of this operation depends evidently on the difference of the electromotive force of silver against nitric acid, and of copper, bismuth and lead against nitric acid, silver being the lowest. But the difference between silver and copper is not great, and a very careful regulation of current density is necessary, which, however, can be attained, making this method one of the neatest applications of electro metallurgy and one which replaces the tedious cupellations necessary by the older process which has come down from the middle ages.

Another application, which is wholly chemical, has recently been made to the purification of sewage near New York.

Many attempts have been made to produce caustic soda and chlorine, or bleaching compounds, from common salt by electrolysis; but thus far they have not advanced to the stage of industrial success. One of the chief reasons for this is because no insoluble anode has been discovered, for in strong solutions platinum is dissolved and carbon is oxidized and corroded; but when the liquid is weak this trouble with the anode is considerably lessened.

A report by Dr. Cyrus Edson, of the Health Office, New York city, partly reprinted in the *Electrical Engineer*, gives an account of a successful experiment recently made to disinfect the sewage of the village of Brewsters, which was finding its way into the city water supply. Mr. Alfred E. Wolf proposed to accomplish the purification of the sewage by treating it with electrolyzed sea water. A current of 700 amperes by 5 volts is delivered to the water as it flows slowly past 7 electrodes. Of these, 4 are carbon, 12″ x 12″ x 1″ thick, while the anodes are copper coated with platinum. The flow of the solution is so limited that the salt water is electrolyzed to the proper degree, and then overflows from the tank directly into the sewer. The disinfection is practically perfect. Tests show that this electrolyzed sea water equals in strength a one per

cent. solution of chloride of lime. In the matter of cost the treated sea water costs 0.01 cent a gallon, while a one per cent. solution of chloride of lime costs 1.4 cents per gallon, or the sea water costs only 1 140th of the lime. Compared with the cost of corrosive sublimate, the latter is 100 times as expensive for an equal efficiency, while carbolic acid costs from 200 to 300 times as much.

Other applications which have been tried and are now on their way to commercial development are: Bleaching fabrics without chlorine by means of electrolyzed acidulated water only, and the tanning of hides.

Seeing that in electrolysis we have a powerful analytic force at work heaping up products of decomposition at each pole, it would be natural to look for some means to utilize the powerful oxidizing and reducing actions of which the electrodes are the foci. This would be to save and turn to useful account the secondary reactions of the cell. A careful study of the conditions under which these secondary actions are a maximum and a minimum can scarcely fail to lead to many applications of the current in technical chemical work where electricity will be used primarily as an oxidizing or a reducing agent, and only secondary as an agent for electrolytic decomposition.

There is one great desideratum, and that is a cheap insoluble anode. Platinum is too expensive, and carbon will not long withstand oxidation. It is this lack which to-day, among other conditions, prevents electricity from being a rival to the ammonia process of making soda, and to the Leblanc process for producing bleaching powder as a bye-product, and to its utilization as an oxidizing agent. When the cheap insoluble anode is found it will open a wide door to the applications of electricity to the chemical arts.

The Rusting of Iron and Steel.

Engineering remarks that the phenomena of chemical combination appear to be exceedingly complex. Not so very many years ago we were taught that a mixture of oxygen and hydrogen would combine to form water when an electric spark was passed through them. The matter appeared simple, was easily expressed in chemical formulæ, and illustrated by experiment. Now we have learnt that it is impossible to make such a mixture explode when it consists of perfectly pure and dry gases. When, however, the slightest trace of moisture is present, the combination takes place at once, thus illustrating the importance of those "next to nothings" which were so ably and so pleasantly discussed by Sir Frederick Bramwell in his address to the British Association. The oxidation of iron, though a more familiar phenomenon, is at least as complex as that of hydrogen. In spite of the proverb, this familiarity has been very far from breeding contempt, as its commercial importance has attracted very considerable attention to the subject, and though there is still much to be learnt, some few facts appear to be now established. In the first place, neither bright iron nor steel will rust in pure water or in pure air. The presence of carbonic acid, or some similar agent, seems necessary, although the final product may be destitute of carbon. Even when oxygen, moisture and carbonic acid are all present, rusting will not, it appaars, take place unless the moisture condenses on the surface of the metal. When rusting does take place under ordinary circumstances, the first stage appears to be the formation of ferrous carbonate. This carbonate is then dissolved in carbonic acid water to form ferrous bicarbonate, which latter is then decomposed in presence of air and moisture to form hydrated ferric oxide, magnetic oxide being formed as an intermediate product. This fact as to the formation of the magnetic oxide is curious, as the Bower-Barff process of protecting iron and steel consists in coating the metal with a firmly adherent layer of this very oxide.

Every one knows that when a bar of iron has commenced to rust, the corrosion proceeds apace. A polished bar will resist oxidation for a comparatively long time, even under somewhat unfavorable conditions, but once the rust has commenced to form, it does not take long for it to cover the whole of the bar. One reason for this may be the fact that the rust is electro-positive to the iron, but it is also partly attributable to the final product, the hydrated ferric oxide, being only formed at the end of several intermediate stages of the oxidation, and to its hygroscopic properties, which favor the absorption of moisture from the air. In certain situations, other acids besides carbonic may take part in the corrosion of iron. The metal work in bridges over railways is particularly exposed to fumes, and some engineers consider that in such cases no plates less than $\frac{5}{8}$ in. thick should be made use of, even in the case of the flooring.

The whole question of the rusting of iron and steel work has been discussed in considerable detail by Mr. Thomas Turner, Assoc. R.S.M., F.I.C., in a paper recently read before the South Staffordshire Institute of Iron and Steel Works Managers. It is now pretty generally acknowledged that, so far as ordinary exposure to the weather is concerned, iron is less liable to rust than steel. Unfortunately, however, this capacity for resisting rust seems to be greater in the common irons than in the best qualities, and has been attributed to the phosphorus contained in the former, which seems to have a protective action. When iron and steel are used in conjunction, there is no certainty which will be the more liable to rust. The potential difference of contact between the two is very small, and though in general wrought iron is found to be electro-positive to steel, there seem reasons for believing that this may not be so in all conditions.

Mr. W. Denny has instanced a case in which the steel shell plates of a vessel remained clean, whilst the iron stem plate and rudder forgings were much corroded. The ballast tanks of ships are particularly exposed to rust. Bilge water is an exceptionally powerful corroding agent, and several engineers have suggested the use of iron plating in ships, in those parts exposed to bilge water, even when the body of the ship is of steel. In steam boilers it is claimed that there is little difference in the behavior of the two metals, and certainly steel boilers, when properly looked after, have been proved to have a long life. Plates thoroughly cleaned from scale are less liable to corrosion than when used just as they come from the rolls; and the Admiralty have accordingly adopted the practice of pickling the plates before being used. In a case of pitting, Mr. John found a particle of black oxide at the bottom of each pit. Experiment shows that this black oxide is strongly electro-positive to the plates.

Cast iron seems in general to last better in sea water than either wrought iron or steel. Trautwine, however, relates that the cast iron cannons of the Royal George and the Royal Edgar, after an immersion of 62 and 133 years respectively, had become quite soft, and were in some cases like plumbago. A very similar experience was noted with the cast iron sluice gates of the Caledonian Canal. Much apparently depends on the quality of the iron. Trautwine recommends white close-grained cast iron, whilst Mr. Turner quotes from a British Association report recommending gray iron.

The alloys of iron with nickel, cobalt and chromium appear less liable to rust than ordinary iron, whilst the presence of manganese appears to render the iron more sensitive to attack by corrosion.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

At the annual meeting of the Portsmouth (N. H.) Gas Company, the following officers were chosen: Directors, Messrs. John Sise, Marcellus Eldridge, H. F. Eldridge and W. W. Colton; President, John Sise; Clerk and Treasurer, F. J. Philbrick; Supt. of Gas Division, T. R. Martin; Supt. of Electric Division, T. F. Flannagan.

We are indebted to a correspondent at Zanesville, O., for the following, which bears date of February 15th: At the annual meeting of the stockholders of the Zanesville Gas Light Company, held Monday, February 12th, the following Directors were chosen: Messrs. M. M. Granger, Robert Fulton, Charles H. Abbott, Alex. Grant and Eugene Printz. This was a re election, except that Mr. Grant was elected to fill the vacancy occasioned by the death of Mr. Howard Stanberry. Mr. Stanberry had been a Director continuously 34 years. The Directors organized by the re-election of the old officers, viz.: Judge Granger, President; G. A. Allen, Secretary; Eugene Printz, Superintendent. The Secretary's annual report made a satisfactory showing, and though there was a falling off in sales the latter part of the year, the net gain for the year was fair, and the Company is satisfied with the outlook for '94. The holder capacity of the Company is insufficient, and the advisability of telescoping the largest holder is under consideration.

The Zanesville Company, we may add on our account, has been particularly progressive in the matter of encouraging the use of gas for cooking and heating, as will be readily understood when it is said that on February 1, 1892, the number of cookers and heaters on its lines was 700, whereas on the 1st inst. no less than 1,500 stoves of all sorts were being supplied with gas. Secretary Allen some years ago inaugurated the practice, on February 1st of each year, of sending to each consumer a statement of the gas consumed by him in the preceding year, together with the average monthly cost of same to the user, and it has borne good fruit. Superintendent Printz keeps on in the even tenor of his way, going right along making good gas at figures which enable the Company to satisfy its patrons and reward its shareholders.

Mr. Thomas H. Gill, who represented the 11th Ward in the Philadelphia City Council from 1862 to 1873, died in Philadelphia on the 15th inst. He was in his 75th year. Deceased was one of the first apprentices of the Southwark Foundry, and upon the completion of his apprenticeship he went to Cuba as chief engineer on a sugar plantation. Upon his return to this country he was employed in the construction of the Philadelphia gas works, of which he was subsequently elected a Trustee.

SENATOR TILGHMAN has introduced a bill in the Maryland Legislature to allow the Town Commissioners of Easton, Md., to issue $50,000 bonds, the proceeds to be devoted to the building of gas or electric light works for that town.

THE administrators of the estate of William E. Callahan, who lost his life, through inhaling illuminating gas, in a room temporarily occupied by him in Mund's Hotel, Boston, Mass., brought suit against the hotel proprietor, William Mund, for $10,000 damages. Plaintiffs among other things claimed that Callahan was ignorant of the methods of using gas, and this claim was fatal to their case, for Judge Sage held that a landlord is not responsible for the ignorance or otherwise of his guests, and instructed the jury to bring in a verdict for the defendant.

SOME time ago we reported the passage by the San Jose, Cal., City Council of an ordinance requiring the filing by the artificial lighting companies of the city of complete returns of their financial standing, general business affairs, and so on. The reply of the San Jose Light and Power Company to this mandate, as made by the Company's Secretary, Mr. W. W. Gitlespie, was about as follows: "Gentlemen—In respect to your communication of January 25, 1894, to the San Jose Light and Power Company, requiring it to file with the Mayor and Common Council a statement of the cost of its works and the amount of the business, etc., for the past year, the undersigned respectfully states to your honorable body that it knows of no law requiring it to file a statement of its private business as is asked for, and is so advised by its attorneys. However, to show your honorable body and the citizens of San Jose that this Company has nothing to conceal in the conduct of its business and the profits therefrom, it will, as far as possible, after the limited notice given, furnish, under protest, the statement desired." The statement begins by asserting that the Company is the successor of four lighting companies, and therefore the cost of the properties and money expended cannot be accurately ascertained, but is estimated at $500,000; that since the organization of the Company, June, 1889, it has expended in extending and enlarging plant, $113,965.13; receipts for the year 1893, $83,257.14; expenditures, $59,466.35; balance, gross gain, $23,791.79; invested during year in permanent improvements and extensions, $7,605.74; net gain for shareholders, $16,186.05.

SOME days ago a petition was handed to the Massachusetts Senate by the Brookline Gas Company asking for authority to increase its capital stock in the sum of $2,000,000. No explanation of what the funds were to be applied to was embodied in the petition, but Mr. A. C. Burrage, counsel for the Company, said the money was wanted to complete the system of extensions already laid out. If the new capital is granted it is not likely the maximum amount will be issued at once.

CRACKSMEN attempted recently to force the safe of the Rochester (N. Y.) Gas and Electric Company, but were foiled by the watchfulness of some of the Company's night employees.

A CORRESPONDENT at Omaha, Neb., forwards the following: "At a special meeting of the City Council of Hastings, Neb., an ordinance was considered the object of which was to grant a franchise to the Hastings Fuel and Illuminating Gas Company. The conditions are that the Company shall invest $5,000 in property before opening the streets, or else furnish the city with a satisfactory indemnity bond. The gas is to be of good quality, with the maximum charge for illuminating use of $1.50 per 1,000, and $1.25 for fuel use. Work must be begun before May 1st, and not less than 4 miles of main are to be in the ground by Nov. 1st. The Company is to lay steel mains. As a partial consideration for the franchise the Company is to furnish the city a certain number of lights free of charge."

THE following is the schedule rate of the Benecia (Cal.) Electric Light and Motor Company: 16-candle incandescent lights, to burn until 10 P.M., $1.50 each per month; to burn until midnight, $2 per month; to burn all night, $3. No charge is made for lamp renewals. The motor schedule is as follows: Small motors, 10 hours' power per working day, $5 for placing and $6.25 per month rental; ½-horse power per working day, $10 for placing and $10 per month rental; ¼-horse power motor per working day of 10 hours, $15 for placing and $15 per month rental; sewing machine motors, $3 per month rental.

UNDER the contract entered into between the County Commissioners and the Indianapolis Gas Company, the authorities will pay the Company for the next five years the sum of $4,300 per annum for lighting the Court House and new jail buildings with gas.

THE rates for gas in vogue at Auburn, N.Y., since the 1st inst., are appended:

Monthly Consumption.	Gross, per M.	Net, per M.
Up to 5,000 cubic feet	$1.50	$1.35
5,000 " to 10,000 cubic feet	1.40	1.26
Over 10,000 "	1.30	1.17

The Auburn folks are evidently desirous of encouraging the use of gas for fuel purposes, as these figures are all very reasonable ones.

THE city of Baltimore, Md., pays, on account of supplies for the public gas lamps of that city, the following prices for the items specified: Top glass, $49 per 1,000; bottoms, $58 per 1,000; white lead, 6 cents per lb.; shamrock green, 12 cents; bronze green, 7 cents; oil, 53 cents per gallon; turpentine, 38 cents per gallon; japanning, 65 cents per gallon.

THE proprietors of the Kewanee (Ills.) Gas Light Company are considering the advisability of adding an electric annex, and the local electric lighting company, per contra, is said to be inclined to go into the gas business. The probability, however, is that an agreement to combine their interests will be the ultimate result.

THE most important contract in water gas circles has just been awarded to the United Gas Improvement Company, of Philadelphia, by the Gas Light Company of the city of New Orleans. By it the former Company agrees to erect at the works of the latter Company a complete water gas manufacturing plant, of its well known form of standard double superheater Lowe apparatus, including all the appurtenances, connections, iron flooring and auxiliary parts of boilers, machinery, etc., necessary for its satisfactory operation. The design covers the usual connections for reversing steam through the generators, and will be, in brief, typical of the very best that this well-known Company can build. In capacity the plant will be of over 1,000,000 cubic feet daily. Construction work under the contract is to be commenced at once, and this new installation of the New Orleans Company will be in full operation by early summer.

AT the annual meeting of the stockholders of the Meriden (Conn.) Gas Light Company the Directors elected were Messrs. Walter Hubbard, Samuel Dodd, J. R. Taylor, F. C. Sherman, E. J. Doolittle, G. M. Curtis and C. F. Linsley.

MR. JOHN D. GAUSS, Representative in the Massachusetts Legislature of the Salem district, is responsible for the adoption of the following order:

Ordered, That the Committee on the Judiciary consider the expediency of the following:

Whereas, Section 5 of Chapter 174 of the acts of the year 1893 provided that it should not be lawful for the Bay State Gas Company to issue any stock or bonds, or to assume any liabilities, or to pay any consideration for or on account of, the principal of a certain obligation for $4,500,000, described in Section 3 of said act, except as therein provided;

Ordered, That the Committee on the Judiciary investigate the conduct of the said Bay State Gas Company in the premises and all matters pertaining to the cancellation and discharge of said obligation, and whether said Bay State Gas Company has issued, or been a party to, or connected with, the issue of stock or bonds, or assumed liabilities, or paid consideration, in violation of the provisions of said act, especially referring to bonds amounting to about $1,300,000, issued directly or indirectly for the purpose of, or as a consideration for, procuring the cancellation and delivery of said obligation. Said Committee to have power to compel the attendance of witnesses and to secure the production of such papers and documents as may be necessary properly to conduct such examination.

THE Hon. T. D. Gilbert, President of the Grand Rapids (Mich.) Gas Company denies that the property thereof has been sold to any syndicate, although he admits that negotiations for its purchase were underway some time ago.

THE bonds of the Belfast (Me.) Illuminating Company, held by the Belfast Savings Bank and the Belfast National Bank as collateral, were sold at auction early this month as advertised. The par value of same amounted to $30,000, and they were knocked down to Mr. James H. Howes, at his bid of $22,500, who resold the bonds to the Belfast National Bank, and steps were at once taken to foreclose on the Illuminating Company's properties, which include the gas works in Belfast and the electric works at Goose river. The Illuminating Company has one year from the beginning of the foreclosure proceedings in which to redeem its property; and the probable outcome will be the formation of a new Company to carry on the business.

For the three months ended January 1, 1894, the Providence (R. I.) Gas Company has paid into the city treasury the sum of $3,527.98, which represents the percentage on its receipts due the city under the franchise act.

Arrangements have been completed under which the plant of the Mutual Electric Illuminating Company, of Westfield, Mass., will come under the control of the Westfield Gas Company.

At the annual meeting of the Petersburg, Va., Gas Light Company, the following officers were chosen: Board of Directors, Dr. H. G. Leigh and Messrs. John G. Dunn, N. T. Patteson, David Dunlop, W. Gordon McCabe and John McGill; President, John G. Dunn.

The sale at auction under foreclosure of the plant, etc., of the Colorado Springs (Col.) Lowe Gas and Electric Company, which was to have been held on January 31st, has been postponed to March 3d.

At the annual meeting of the shareholders in the Leominster (Mass.) Gas Light Company, the following officers were elected: Directors, N. Harwood, George F. Morse, Cephas Derby, George Hall and H. M. Lane; President, Nahum Harwood; Clerk and Treasurer, H. M. Lane.

At the annual meeting of the Boston Gas Light Company the retiring Board of Directors was re elected, and Mr. J. E. Addicks was again chosen President.

A correspondent at Newark, N. J., forwards the following clipping from a recent issue of the Elizabeth (N. J.) *Herald:* "Some two or three weeks ago A. W. Bautch, proprietor of a restaurant, removed his place of business from the corner of First and Marshall streets to 125 Elizabeth avenue, where he opened in grand style. Bautch in fitting up his place had economic views, it appears, for instead of burning plain, everyday kerosene oil, he concluded to burn gas, his fertile brain having told him that he could enjoy this luxury without charge. Instead of going to the office of the Gas Company and making arrangements for the distribution of gas throughout the premises, Bautch simply called in a local plumber, had him tap the street main, run a pipe through the restaurant and locate thereon several gas burners. An official of the Gas Company discovered Bautch's little scheme, and shortly thereafter an officer visited the restaurant and found the place brilliantly illuminated with gas and Bautch attending to his business serenely. The officer had in his possession a warrant for Bautch's arrest, and the greatly surprised man was marched off to Police Headquarters, where a charge of larceny preferred by the Gas Company was entered against him. Bautch was released on bail, and will have to answer later for his offense. The Gas Company officials are not prepared to say how long Bautch had been burning their light. They say, however, that he had several burners, one of which was used in a gas stove in the kitchen."

A correspondent at Sacramento, Cal., forwards the following: The bid of the Capital Gas Company for lighting the city of Sacramento was read before the Board of City Trustees on the evening of the 12th inst., and Trustee Kent moved that a contract be made with the Company till January 1, 1895. Trustee Bragg moved as a substitute that the proposed contract be referred to the City Attorney for his opinion as to the time the contract can be made for. The substitute prevailed. The following is the bid and specifications:

"*To the Board of Trustees of the City of Sacramento*—Gentlemen: We propose to light the city of Sacramento with electric lights in accordance with the specifications hereunto attached and made part of this proposal, for a period of one year, from 12th day of February, 1894, for the sum of $14.95 per month for each and every lamp as located by the Trustees, used in lighting the city, the amount to be paid monthly at the end of each month. We inclose certificate of deposit for $1,000, payable to the City Clerk as required by the specifications on file in the City Clerk's office, as a guarantee that we will enter into a contract for the performance of the above work, in the event of our bid being accepted.

"Capital Gas Company, by J. C. Pierson, Supt."

The specifications are as follows: The lamps to be furnished are to be of the standard 2,000-candle power arc lamps. The number of lamps required is 151, or more, as directed by the Board of Trustees. All lamps are to be suspended over the intersections of the streets, except when otherwise directed by the Board of Trustees. The location of the lamps may be changed at any time by the direction of the Board of Trustees; provided that after the location of a lamp is once fixed the city shall pay exact cost of making any change. The height at which lamps are to be suspended over the intersections of the streets shall be 30 feet, and no wire shall be hung so low as to interfere with street traffic. New lamps shall be placed at such places as directed by the Board of Trustees, without expense to the city of Sacramento, provided all such lamps shall be ordered placed during the first eight months of the period covered by this contract. The wires and conductors shall be thoroughly insulated and placed in such location and in such manner as will prevent them from being tampered with or handled by any unauthorized person or persons. It is distinctly understood that the city shall not be responsible, but must be held blameless against any claim or claims for damages caused by any injury or accident which may be occasioned by the wires, conductors, or any part of said electric system, and for any claim for damages by reason of any infringement of any patent right in the use of lamps or appliances connected with the said electric lights. The lamps are to be fitted with appliances which will render them capable of burning for at least 13 consecutive hours. The lamps to be lighted one half hour after sunset and to be extinguished one-half hour before sunrise. During the night of full moon and the four nights preceding and the four nights succeeding the full moon no lamps shall be lit, except when the moon is obscured by clouds. It will also be necessary to light the lamps during some portion of the three nights preceding the night before the full moon and the three nights succeeding the night after the full moon.

The roof of the new electric light station for the Citizens Electric Light, Heat and Power Company, at Lancaster, Pa., is to be furnished by the Berlin Iron Bridge Company, of East Berlin, Conn.

The proprietors of the Oshkosh (Wis.) Electric Light Company, tired of going on with the philantropy which prompted them to furnish 1,200-candle power arcs for the public lighting on the basis of a payment of $52 per year each, have notified the city that hereafter the work cannot be done for less than $75 per arc per annum. A moontable is followed.

The proprietors of the Honesdale (Pa.) Gas Company have issued the following new schedule of selling rates: 1,000 cubic feet and under, per month, $2.50 per 1,000; 2,000 cubic feet and under, $2; 3,000 cubic feet and over, $1.75; 5,000 cubic feet and over, $1.50; 10,000 cubic feet and over, $1.25.

At the annual meeting of the shareholders in the Gas Light Company, of Augusta, Ga., the following officers were chosen: Directors, Messrs. George T. Barnes, P. H. Langdon, Leonard Phinizy, J. B. Schneider and Thomas R. Wright; President, Geo. T. Barnes; Secretary, H. B. Adam. The annual reports showed the Company's business to be in good shape.

Mr. E. S. Pearson, Assistant Treasurer of the Philadelphia (natural) Gas Company, died at his home in Pittsburgh, Pa., on the morning of the 16th inst. He was in the 36th year of his age.

The Baltimore *American*, speaking of the proposition to list the shares of the Consolidated Gas Company, of Baltimore, on the New York Stock Exchange, says: "With regard to the proposed listing of Baltimore Consolidated gas stock in New York, the officials here say that there is nothing new to say in regard to it, but state simply that the committee has submitted a favorable report and that the matter is only waiting to be called up in order to go through. There appears, however, as is stated on the outside, to be some doubt of the matter being called up for some time, owing to the present condition of the market, those in a position to know saying that the Gas Company officials have no desire to have the stock 'hammered' on the New York Exchange, which would likely have been the case some months ago, and still might be its fate if listed in New York. One banker here said some time ago that the Company appeared to be getting more than ever into a close corporation, very little gas stock, comparatively, changing hands."

The American Gas Process Company, of New York city, has been incorporated by Messrs. Edwin R. Ellsworth and George A. Viemiester, of Brooklyn, and Edward Egenberger, of New York. It is capitalized in $10,000, and its purpose is to manufacture gas machines.

The proprietors of the Erie (Pa.) Gas Company have announced that hereafter the price of gas for cooking, heating and power purposes in that city shall be $1.20 per 1,000 cubic feet, with 20 cents off for prompt payment.

Some time ago Messrs. J. C. Hubinger and others applied to the City Council of Keokuk, Iowa, for a franchise for the operation of a gas and electric lighting plant in that city. The application was referred to the Judiciary Committee, and the members thereof subsequently handed in an adverse report. The reasons given for this adverse action were substantially that the city was not large enough to support two gas works, and that the erection of another meant bankruptcy for one or the consolidation of both.

From the annual report of the Salem (Mass.) Gas Light Company we learn that the gain in sendout for 1893 over 1892 amounted to 4 per cent.

At the annual meeting of the Citizens National Gas Company, of Stockton, Cal., it was decided to raise the selling rate from 75 cents per 1,000 cubic feet to $1 per 1,000 cubic feet for the first 5,000 feet used, the charge for each 1,000 over the last named figure to be 75 cents.

The iron roof over the dye house for Messrs. Geo. C. Hetzel & Co., at Chester, Pa., will be furnished by the Berlin Iron Bridge Company, of East Berlin, Conn.

Messrs. Wehner & White have leased and are operating the El Paso (Texas) Gas, Electric Light and Power Company.

The Market for Gas Securities.

More proposed legislation in respect of gas prices is reported from Albany, and it is traceable to that most unique specimen of a reformer, whose main claim to fame, before he was chosen to represent a Senatorial district of Kings county, rested on his ability to tend bar successfully. Senator Owens is the party referred to, and he asks the State to decree that hereafter the price of gas in cities of New York State, having 100,000 inhabitants or less, shall not be more than $1.40 per 1,000 cubic feet; in cities of from 200,000 to 500,000, $1.25, and in cities of more than 500,000, $1. He also asks that the quality of gas furnished "be regulated." It is, of course, rather early to predict the ultimate fate of the Owens strike, but it is safe to say it will either die easily or be strangled. Consolidated is steady to strong, at 125 to 125½, and other city shares are firm.

Brooklyn securities are unchanged, but we look for lower prices in them before long. Chicago gas is weak and ragged; the opening in it to-day (Friday) was made at 62½ to 63. Consolidated of Baltimore shows no change from last week, and Bay State is in good request, at 18 to 18½. The proposition in the New Jersey Legislature to pass a bill cutting gas rates all over the State has caused some unsettlement of values there, but the status of the Legislature itself is such that holders need not have much fear that the measure will ever become law.

Gas Stocks.

Quotations by Geo. W. Close, Broker and Dealer in Gas Stocks,
16 Wall St., New York City.

February 26.

☞ All communications will receive particular attention.
☞ The following quotations are based on the par value of $100 per share. ☜

	Capital.	Par.	Bid	Asked
Consolidated	$35,430,000	100	125	125½
Central	500,000	50	90	95
" Scrip	220,000	—	—	100
Equitable	4,000,000	100	180	185
" Bonds	1,000,000	—	106	108
Harlem, Bonds	170,000	—	—	—
Metropolitan, Bonds	658,000	—	108	112
Mutual	3,500,000	100	145	148
" Bonds	1,500,000	—	100	102
Municipal, Bonds	750,000		—	—
Northern		50	80	95
" Bonds	150,000	—	—	100
Richmond Co., S. I.	346,000	50	50	65
" Bonds	20,000	—	—	—
Standard Gas Co—				
Common Stock	5,000,000	100	—	32
Preferred	5,000,000	100	—	77
Yonkers		50	112	—
Gas Co's of Brooklyn.				
Brooklyn	2,000,000	25	—	110
Citizens	1,200,000	20	55	—
" S. F. Bonds	320,000	1000	—	101
Equity Gas Light Co	2,000,000	100	—	—
Bonds	1,000,000	—	25	40
Fulton Municipal	3,000,000	100	137	—
" Bonds	300,000		103	—
Peoples	1,000,000	10	80	83
" Bonds (7's)	368,000	—	100	—
" " (6's)	94,000	—	98	100
Metropolitan	870,000	100	—	140
" Bonds (5's)	70,000	—	100	—
Nassau	1,000,000	25	160	—
" Ctfs	700,000	1000	99	100
Williamsburgh	1,000,000	50	135	—
" Bonds	1,000,000	—	107	110
Out of Town Gas Companies.				
Bay State Gas Co.—				
Stock	5,000,000	50	18	18½
Income Bonds	2,000,000	1000	40	—
Boston United Gas Co.—				
1st Series S.F. Trust	7,000,000	1000	78	—
2d " " "	3,000,000	1000	57	58
Buffalo Mutual, N. Y.	750,000	100	110	—
" Bonds	200,000	1000	95	100
Citizens, Newark	1,000,000	50	155	160
Chicago Gas Company.	25,000,000	100	62½	63
Chicago Gas Light. & Coke Co.—				
G't'd Gold Bonds	7,650,000	1000	81⅛	81⅝
Consumers Gas Light Co., Jersey City	2,000,000	100	27	33
Bonds	600,000	1000	85	88
Cincinnati G. & C. Co.	7,000,000	100	192	—
Consumers Toronto	1,600,000	50	184½	187
Central, S. F., Cal			—	100
Capital, Sacramento, Cal			—	55
Consolidated, Balt.	11,000,000	100	—	58½
" Bonds	6,400,000		107	107½
Citizens Gas Lt. Co., Rochester, N. Y.	500,000	—	85	101
Bonds	250,000		—	—
Detroit Gas Co.—				
1st Mortgage	.....	.....	56	—
East River Gas Co., Long Island City	1,000,000	100	—	—
Bonds	500,000	100	89¼	—
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1000	—	101
Hartford, Conn	750,000	25	120	128
Jersey City	750,000	20	190	200
Louisville, Ky	2,570,000	50	125	130
Laclede Gas Light Co. St. Louis, Mo.—				
Common Stock	7,500,000	100	15½	16
Preferred "	2,500,000	100	62	65
Bonds	9,034,400	1000	83½	84
Little Falls N. Y.	50,000	100	—	100
" Bonds	25,000	—	100	103
Montreal, Canada	2,000,000	100	200	208
Memphis (Tenn.) Gas	750,000	100	30	—
" Bonds.	240,000	100	103	—
New Haven, Conn		25	200	—
Oakland, Cal			42⅝	43

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We will receive bids for 3,500 bbls. Tar, to be delivered during 1894. Bids to be opened March 15.
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978-8 Buffalo, N. Y.

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The Bristol (Pa.) Gas Light Company will receive bids for their Tar Product from March 1st, 1894, to March 1st, 1895.
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Bids will be opened March 1, 1894, at 4 P.M., at the office of the Company in Bristol, Pa.
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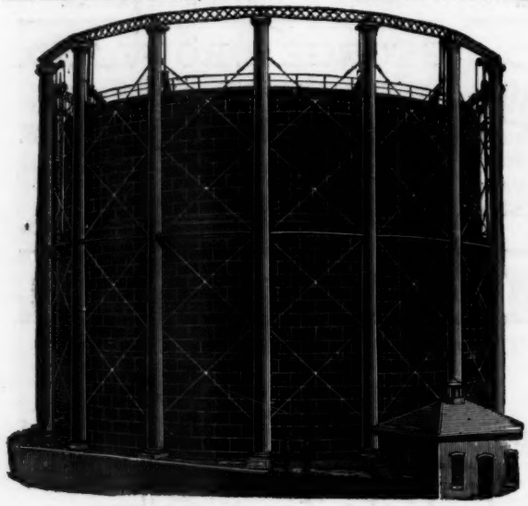

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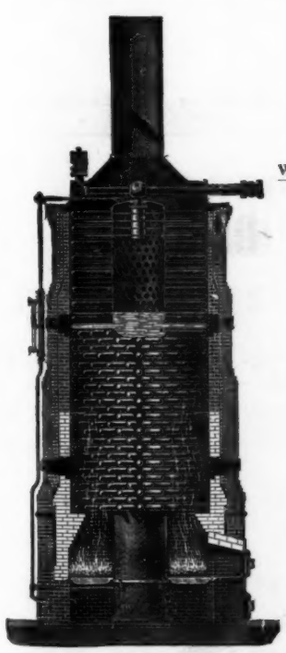

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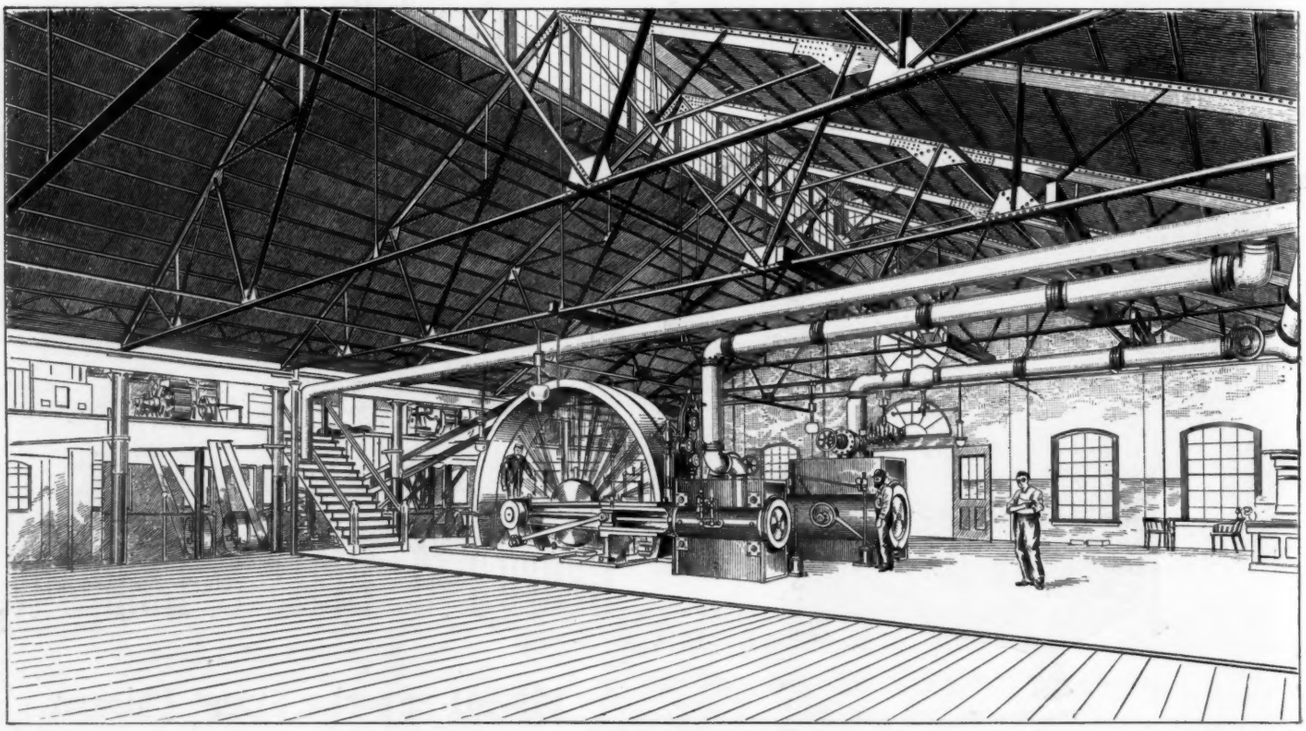

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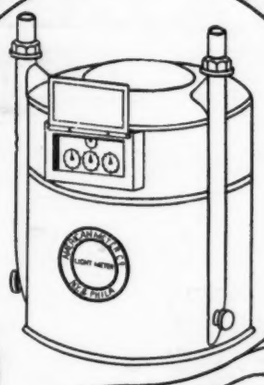

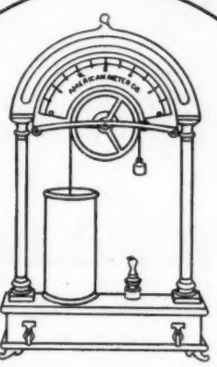

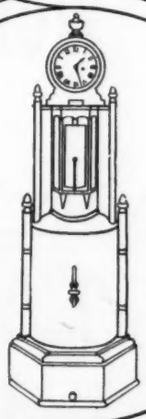

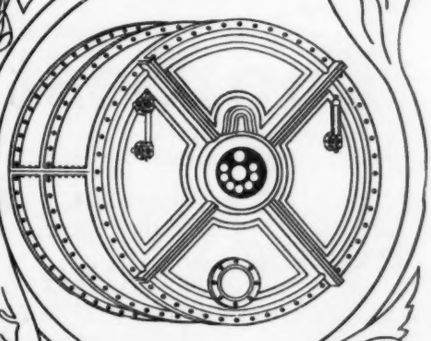

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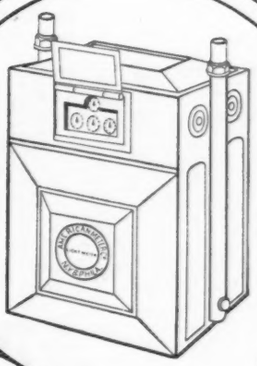
PUBLIC LIGHTING TABLE.

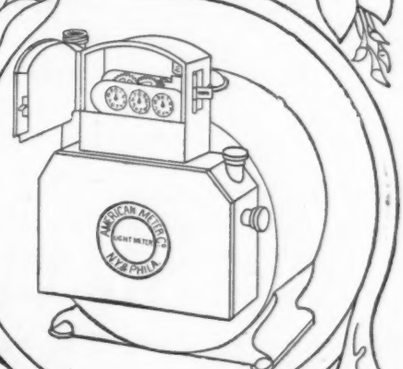
MARCH, 1894.

Day of Week.	Date.	Table No. 1. Following the Moon. Light.	Table No. 1. Following the Moon. Extinguish.	Table No. 2. New York City. All Night Lighting. Light.	Table No. 2. New York City. All Night Lighting. Extinguish.
				P.M.	A.M.
Thu.	1	6.20 PM	5.00 AM	5.30	5.45
Fri.	2	6.20	5.30	5.30	5.45
Sat.	3	6.20	5.30	5.30	5.45
Sun.	4	6.30	5.30	5.30	5.45
Mon.	5	6.30	5.30	5.40	5.35
Tue.	6	6.30	5.30	5.40	5.35
Wed.	7	6.30 NM	5.20	5.40	5.35
Thu.	8	6.30	5.20	5.40	5.35
Fri.	9	6.30	5.20	5.40	5.35
Sat.	10	6.30	5.20	5.40	5.35
Sun.	11	6.30	5.20	5.40	5.35
Mon.	12	11.00	5.20	5.50	5.20
Tue.	13	12.20 AM	5.20	5.50	5.20
Wed.	14	1.20 FQ	5.10	5.50	5.20
Thu.	15	2.20	5.10	5.50	5.20
Fri.	16	3.10	5.10	5.50	5.20
Sat.	17	3.50	5.10	5.50	5.20
Sun.	18	4.20	5.10	5.50	5.20
Mon.	19	No L.	No L.	6.00	5.10
Tue.	20	No L.	No L.	6.00	5.10
Wed.	21	No L. FM	No L.	6.00	5.10
Thu.	22	6.50 PM	8.40 PM	6.00	5.10
Fri.	23	6.50	9.50	6.00	5.10
Sat.	24	6.50	11.00	6.00	5.10
Sun.	25	6.50	12.00	6.00	5.10
Mon.	26	6.50	1.10 AM	6.10	4.55
Tue.	27	6.50	2.00	6.10	4.55
Wed.	28	6.50	3.00	6.10	4.55
Thu.	29	6.50 LQ	3.40	6.10	4.55
Fri.	30	6.50	4.20	6.10	4.55
Sat.	31	6.50	4.40	6.10	4.55

TOTAL HOURS LIGHTING DURING 1894.

By Table No. 1.	Hrs. Min.	By Table No. 2.	Hrs. Min.
January	244.10	January	423.20
February	195.30	February	355.25
March	206.20	March	355.35
April	169.40	April	298.50
May	162.10	May	264.50
June	135.40	June	234.25
July	146.30	July	243.45
August	162.20	August	280.25
September	174.10	September	321.15
October	211.20	October	374.30
November	221.00	November	401.40
December	245.30	December	433.45
Total	2274.20	Total	3987.45





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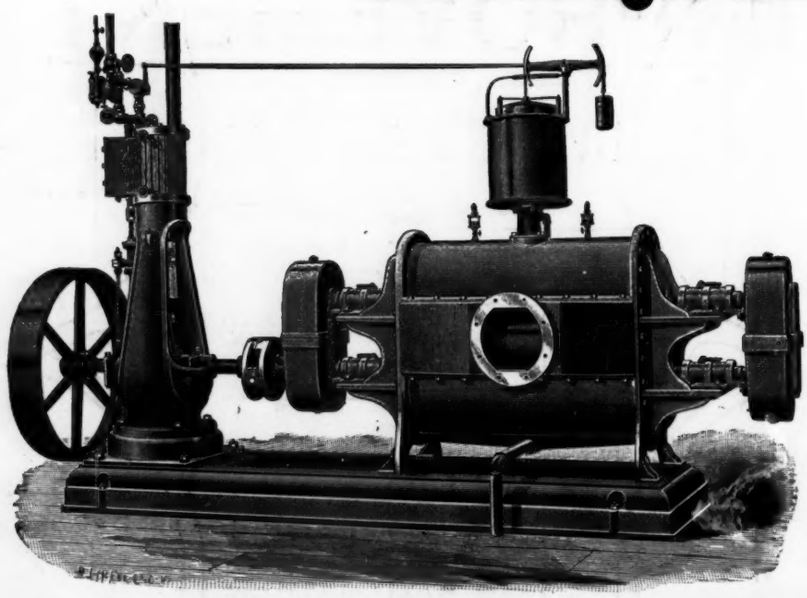

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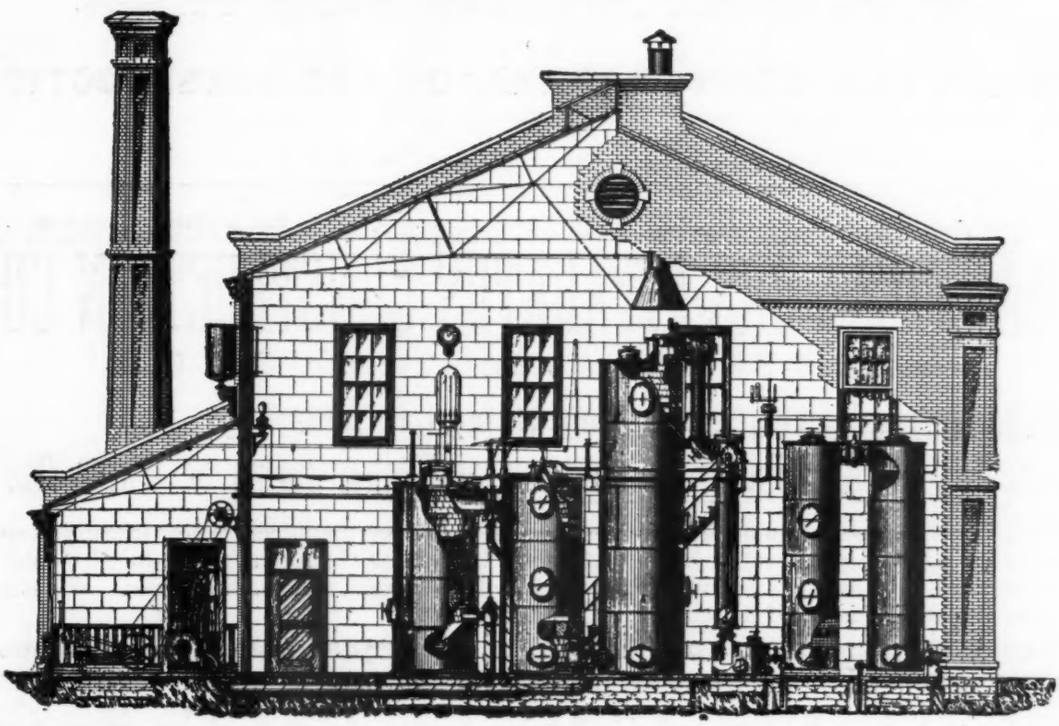

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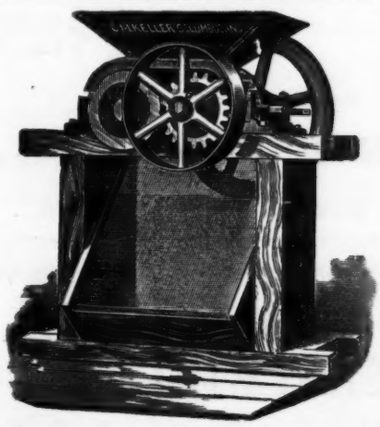

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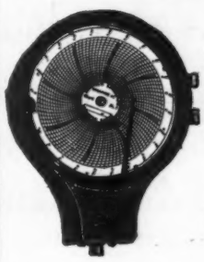

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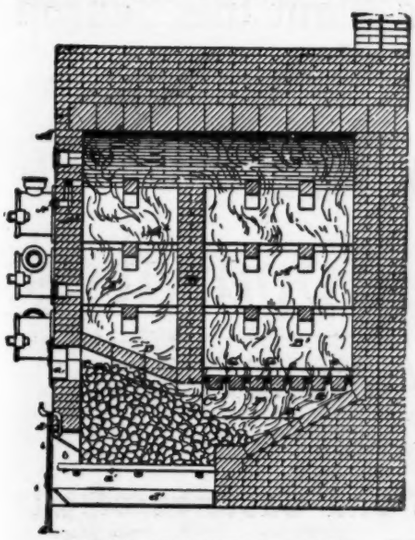

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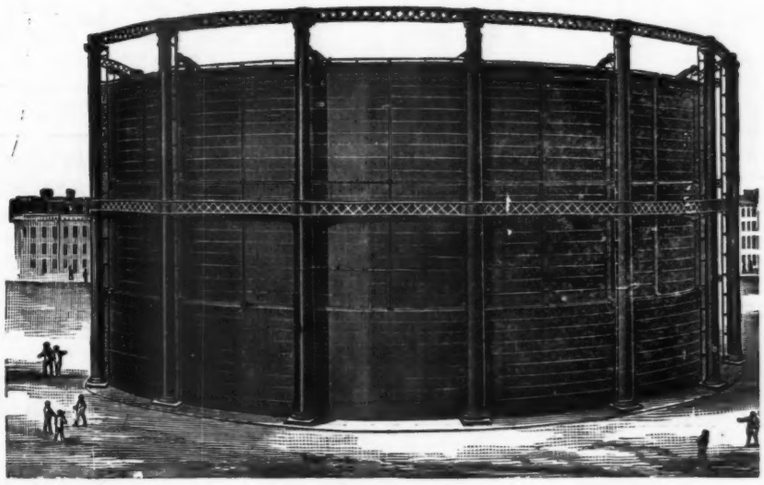

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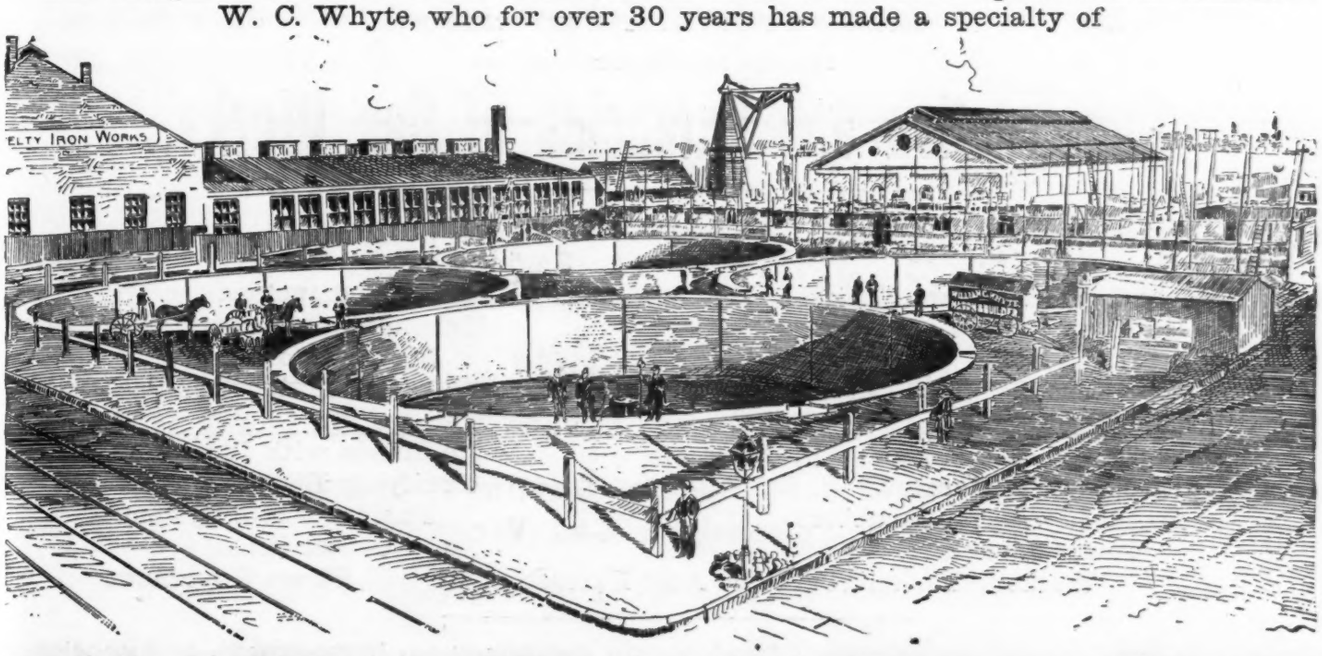

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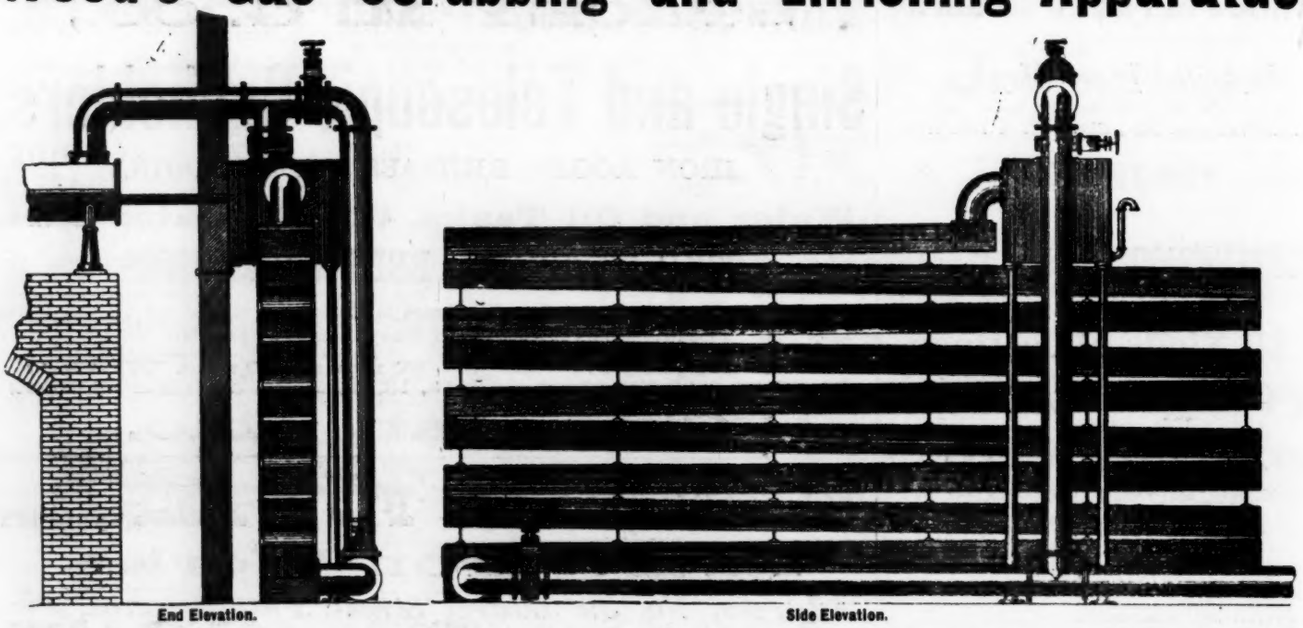

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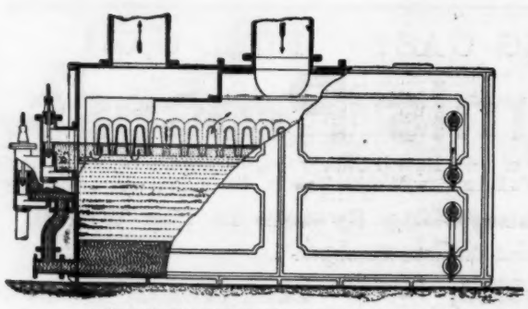

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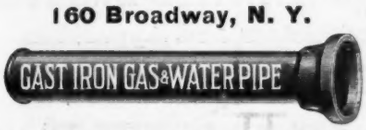

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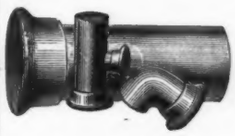

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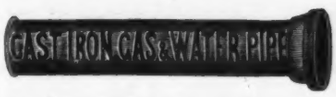

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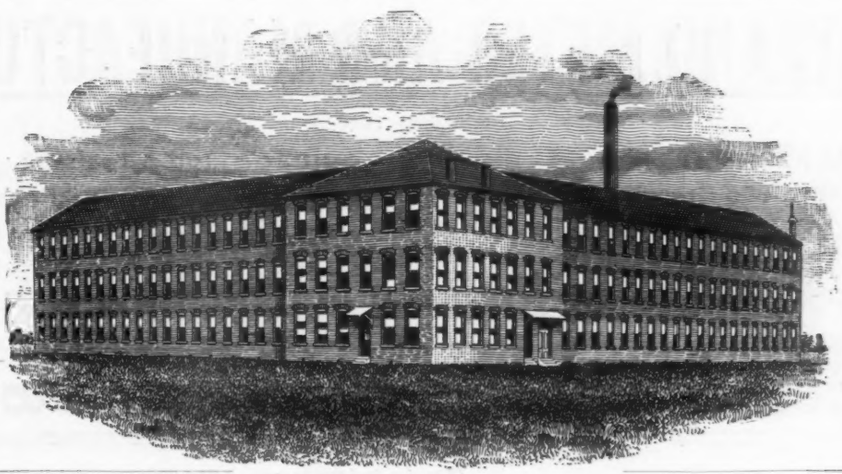

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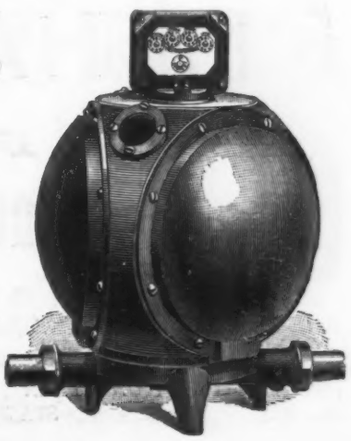

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